S OF THE MODERN WORLD

D. V. SEARLE

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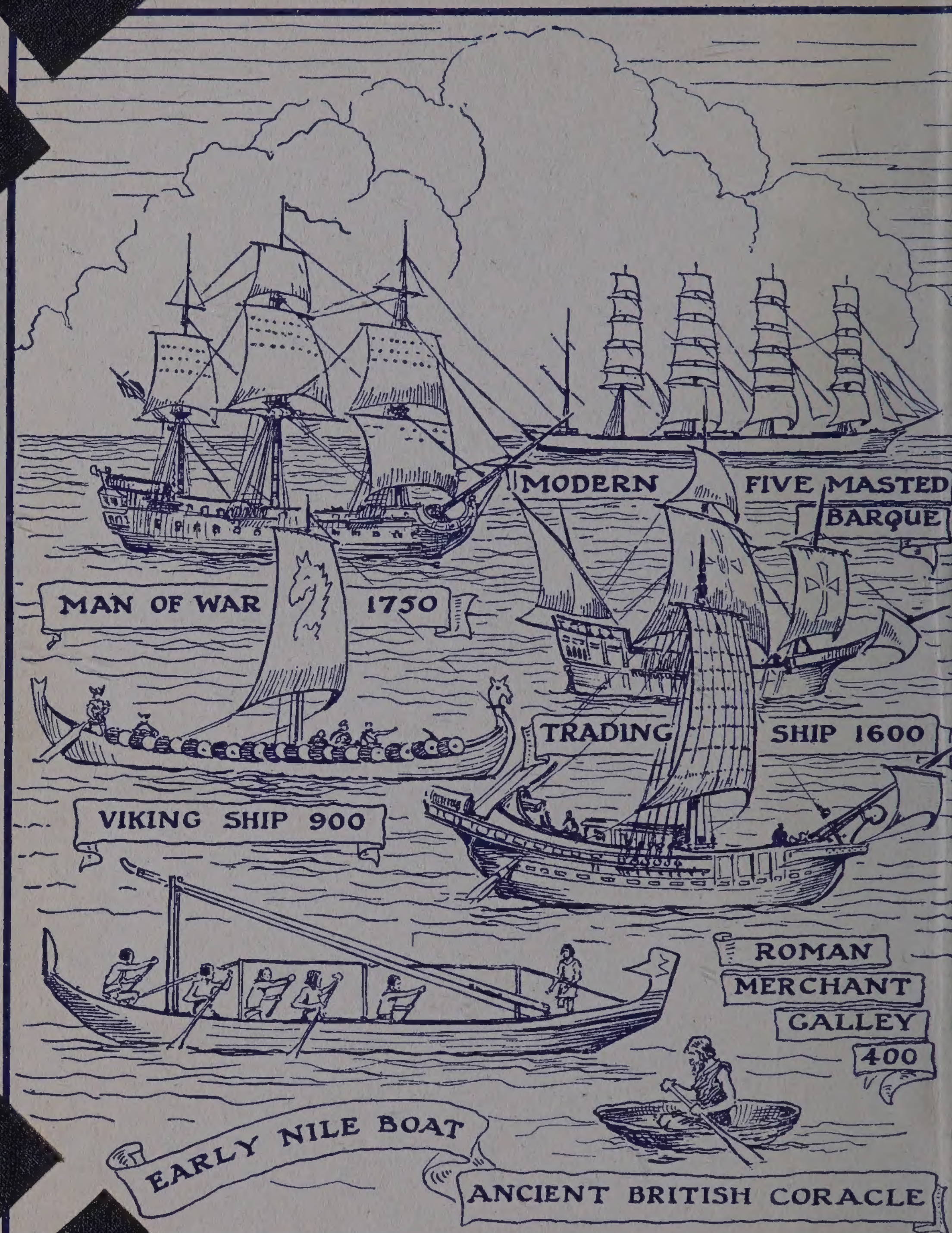
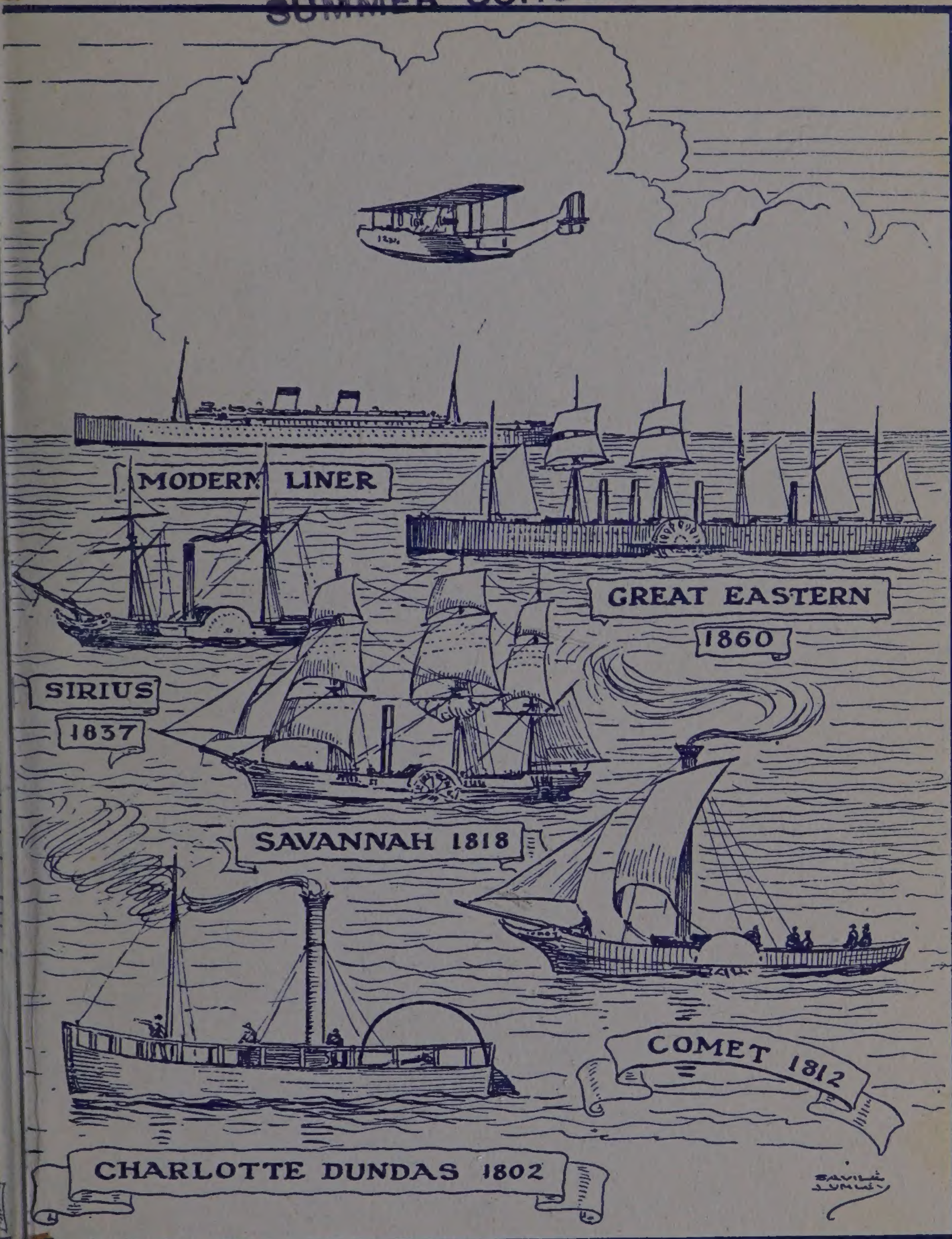

MODERN FIVE MASTED BARQUE
MAN OF WAR 1750
TRADING SHIP 1600
VIKING SHIP 900
ROMAN MERCHANT GALLEY 400
EARLY NILE BOAT
ANCIENT BRITISH CORACLE


MODERN LINER
GREAT EASTERN
1860
SIRIUS
1837
SAVANNAH 1818
COMET 1812
CHARLOTTE DUNDAS 1802
SAVILE LUMLEY

THE "A.L." SENIOR HISTORIES

(History through Biography)

BOOK VII

MAKERS OF THE MODERN WORLD

BY

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CONTENTS.

INTRODUCTION.

IN this book you will read about some of the men whose inventions and discoveries have made such changes in the life of this country and other countries during the last two hundred and fifty years.

If we could peep at England as it was when William of Orange came over from Holland, in 1688, to take the Crown, we should find very few large towns, no good roads, and not nearly so many people as there are to-day. There were no big factories; no great iron-works sent clouds of smoke from their tall chimneys; there was no gas or electric light in the streets or houses, even in London. When people wanted to go from one part of the country to another, they had to travel in big lumbering coaches, in wagons, on horseback, or on foot.

Stage coaches ran between London and many of the big towns, such as York, Exeter, Chester, and Bristol. But it was not until 1774 that a coach began to run from Manchester and Liverpool to London three times a week, and though the journey could be done in three days, bad weather and bad roads sometimes delayed it for ten days, or even a fortnight.

A sea voyage was even more risky, for there were no steamships, only sailing vessels. These were often driven out of their course, becalmed, or otherwise delayed. It was impossible for merchants in those days to bring to England the fruits and other things that we see every day in the shops. A journey to America took six weeks, often two months. To reach India might take any time from three months to a year.

There was no post office to carry letters and parcels; telegraph and telephone were alike unknown; newspapers were few and very dear. News travelled very slowly. Soon after William III became king, a terrible massacre of a Highland clan took place at Glencoe, in Scotland; but news of it did not reach London for nearly a year.

There were no fine hospitals in those days, as there are to-day, in which even the poorest people can have the best doctors and nurses. Many of the wonderful medicines and appliances doctors now use were then unknown. People who were injured or sick had to suffer terrible pain, and often die, because so little was known about surgery and nursing.

All the modern wonders—gramophones, wireless telegraphy and telephony, cinemas, aircraft, and such like, would have appeared like incidents out of a fairy tale to a boy or girl who lived two hundred and fifty years ago.

This book tells of some of the men and women who have helped to make this modern world of ours what it is.

1. THE "NEW FARMERS" AND THEIR WAYS.

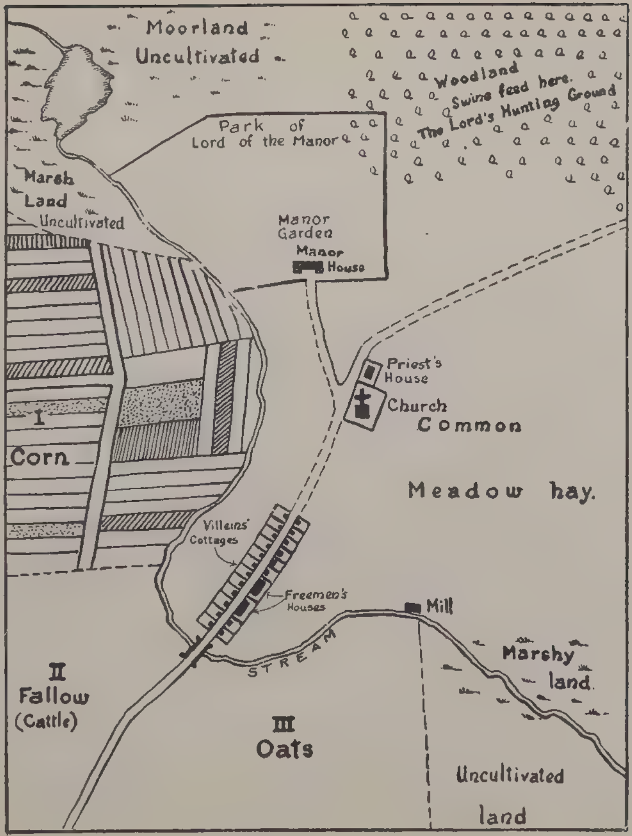
(*a*) The Old Way of Farming.

England of the eighteenth century was still a farming country. It was not until the early nineteenth century that steam engines and machinery came into general use, and great factories and busy towns sprang up.

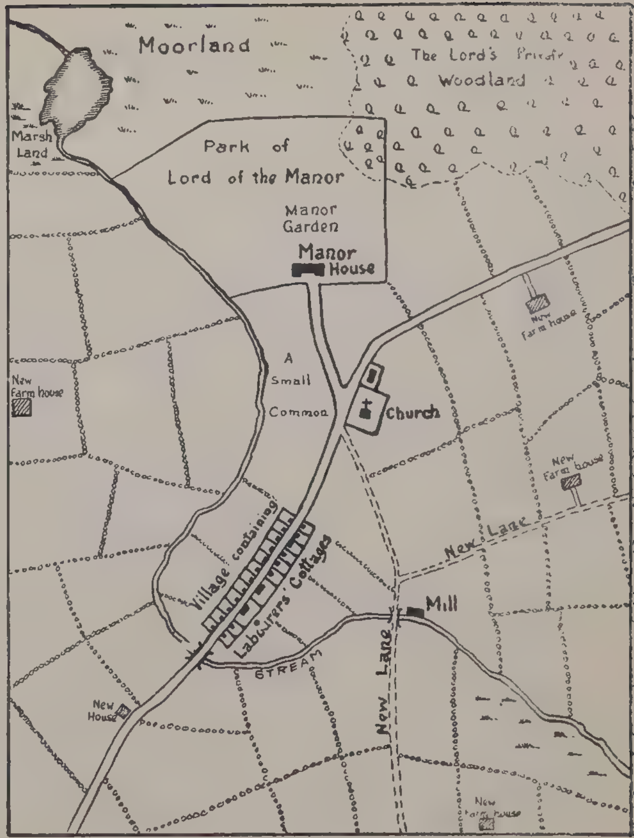
During the last two hundred years, however, many changes have taken place in farming, and a farmer of the time of William III would be as much surprised to see modern farm machinery as his brother, if he happened to be a weaver, would be at the sight of a modern cloth mill.

Although in the south-east of England much of the land has for centuries been enclosed within hedges, as we see it to-day, there were, right up to the eighteenth century, great blocks of land still farmed in the old way, in open fields. Around the village lay three big fields of ploughland, each divided into many little strips, each strip separated from the next by a boundary of coarse grass, called a balk. (See the diagram on page 2.) There were fences round the outside of the ploughlands to keep the cattle from straying, but no fences between the strips. By the stream was the hay meadow; its crop was shared by the villagers, whose cattle and sheep fattened on its young grass after the harvest.

On the ploughland wheat and oats, barley and rye were grown. Although a few farmers, even in the seventeenth century, had begun to grow clover and turnips, many of the villagers had never thought of sowing these new-fashioned crops. As they had not yet learned how to manure their land, they could not grow crop after crop without giving the land a rest. So,



Plan of a manor, when the old three-field system was in operation.



Plan of the same manor after the "enclosures" had taken place (*see page* 1).

every year, one of the three big fields of the ploughland was left idle, with cattle and sheep feeding on the grassy balks.

A heavy wooden plough was used on the land. It often needed six, eight, or even twelve oxen to draw it through the soil. Seed was sown broadcast. Wheat and rye were reaped with a short sickle; barley and oats, as well as hay, were cut with a long-handled scythe. Groups of women and children followed the reapers to gather up and bind the sheaves.

There were no threshing machines, the corn being threshed with a flail, which was made of two wooden rods, one three feet long and the other two feet, joined together by a strong piece of leather. The thresher grasped the longer rod in his hands, swung the shorter one in the air, and brought it down upon the corn spread on the floor of the barn.

All the cattle, sheep, and pigs of the village were put together and watched by the herdsman, the shepherd, and the swineherd. In the autumn, when the grass became scanty, most of the animals were killed, and the meat was salted or pickled; so for six months people rarely tasted any fresh meat.

The old style of farming was very wasteful; for men wasted time in going from strip to strip, and land was wasted by lying idle. Men did not have the same strips year after year, and a careful farmer's work might be ruined, the next season, by a careless neighbour. It was also possible that disease might spread through all the cattle, if one man neglected to look after his beasts.

The ordinary farmer could not afford the time or the money to try new ways; but there were rich men who could do so, and, by their help, great discoveries were made, and changes took place.

Farming operations in olden days. (*a*) Ploughing; (*b*) Sowing; (*c*) Threshing with flails; (*d*) Cutting down the corn with sickles; (*e*) Piling the corn into stooks; (*f*) Carting the corn to the barns. N.B.—This seems much the hardest task of all for the reapers.

British Museum.

(*b*) Two of the "New Farmers."

JETHRO TULL (1674–1741).
"TURNIP" TOWNSHEND (1674–1738).

One of the "new farmers" was a Berkshire gentleman, Jethro Tull. He was educated at Oxford, and, in 1699, became a barrister; but his health was bad, so he gave up the law, and settled down on his father's land at Howberry, near Wallingford, in North Berkshire, as a farmer.

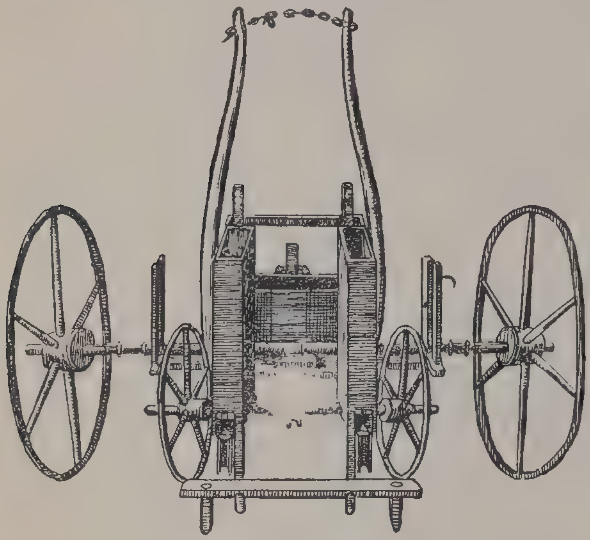
At this time, farmers were just beginning to grow turnips as winter food for cattle and sheep, but the crops were very poor. Tull kept his eyes open, and tried to find a better way of growing this crop, for he saw that it would be very useful. He found that there were two faults: the seed was sown too thickly, and the ground was not hoed properly.

About 1701, Tull invented a machine called a drill, which looked like a box hung between two big wheels. Leading down from the box were tubes, the open ends of which made little furrows in the soil; at the same time grains of seed dropped from the box down each tube into the furrows. At the back of the machine was a wooden rake that drew the earth over the seeds. The machine was drawn by a horse.

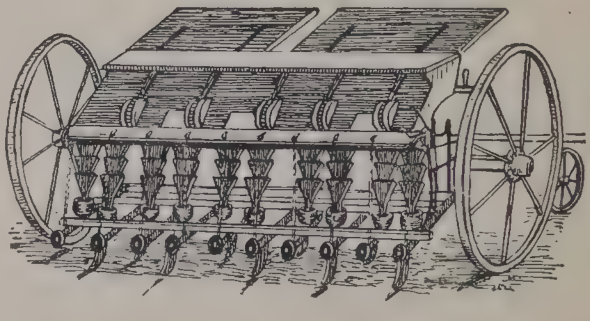
Seed sown in this way came up in regular lines, and the weeds could be removed by hoeing between the rows.

The old broadcast way of sowing was done by hand. A man hung a basket of seed round his neck in front of him, and as he walked up and down the field, he took out handfuls at a time, and scattered it to the right and to the left. But this was a wasteful method. Some of the seed did not fall into the furrows at all, and was snatched

away by the birds ; some fell close together, and had no room to grow ; other places were nearly bare. When the crop began to grow, it was almost impossible to weed it, for the plants were uneven, and not in regular rows.


Jethro Tull's drill.
From "The Horse-Hoeing Husbandry.'

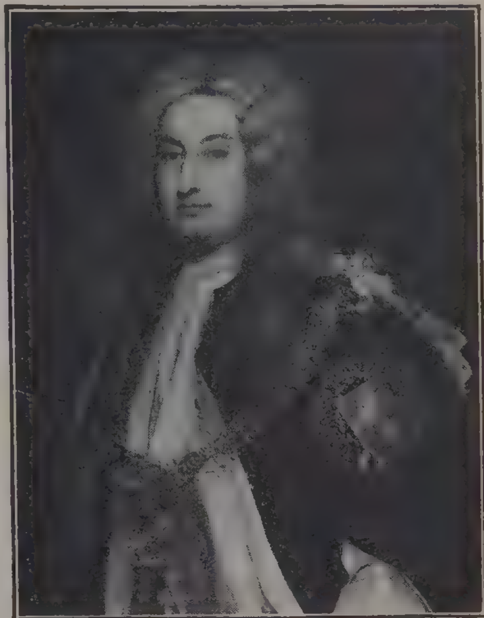
Tull travelled in France and Italy, and studied the farming in these countries. He also made a number of experiments and researches for himself, and was able to show, for instance, that the roots of plants spread much farther than had been thought. He discovered that the roots could take in food from soil, only when it was broken up very finely.


A modern drill. Some are much larger than the one illustrated, but they are similar in principle.

In 1733, Tull wrote a book entitled *The Horse-Hoeing Husbandry*, in which he proved that hoeing not only was necessary for clearing weeds, but also made it possible to grow a good crop in a dry summer, by breaking up the little channels or "tubes" in the soil, through which, in dry weather, moisture is always coming to the surface and passing into the air. The hoe breaks

the tops of these little "tubes." The moisture is then saved to feed the plants, instead of escaping.

Among the gentlemen who followed Tull's advice about farming, was Lord Charles Townshend, brother-in-law of Walpole, the famous Prime Minister. After holding office as Secretary of State, Townshend retired from politics in 1730. He settled on his estate at Raynham, in Norfolk, and became interested in farming.



Lord Charles Townshend.
National Portrait Gallery.

He tested the plan of growing crops of turnips and clover between two corn crops, and found it worked well, so there was no need to let the land lie idle every third year. This method of growing four crops in order, one after the other, is called the "Norfolk course" or the "Norfolk rotation." Because Townshend grew turnips on a very large scale, he earned the nickname of "Turnip" Townshend.

On Townshend's Norfolk estate the soil was light and sandy. Up to this time it had been said that "two rabbits fought for every blade of grass"; but now a new prosperity set in, and, by the end of the century, Norfolk had become one of the best cultivated counties in England.

(*c*) The Enclosures.

As the "new farming" could not be carried on in places where the old open fields remained, many farmers wanted their land enclosed in fields, and to do away with the scattered strips. This could be done only by Act of Parliament. When the principal farmers in a parish asked to be allowed to enclose their land, a commissioner was sent from London to find out about the rights of each villager. Then, if the Act was passed, the land was re-divided, each man receiving a certain compact holding or farm, instead of the old-fashioned strips. This holding he was expected to enclose by fences or hedges.

To many farmers enclosures were very helpful. They were able to employ the new ideas in their farming without interference, and they often made their land four or five times as productive as their old strips had been. But the poorer men, who owned only a few strips, could not afford to pay for fences and new tools, so they were forced to sell their bit of land to a wealthier neighbour, and work as labourers on other men's land.

One of the greatest hardships was the loss of the right to keep a cow, a pig, a donkey, or a few geese on the waste land. Many cottagers who owned no land, had enjoyed this right, and so had their fathers and grandfathers before them. But when the re-distribution took place, attention was paid only to people's legal right, and no notice was taken of those old customs, which many poor people had exercised from time out of mind.

When England was at war with Napoleon, the pastures were ploughed up, and turned into cornfields. It was then that the advantages of the "new farming" were seen. Under the old conditions England would not have been able to feed her growing population through such a long war.

(*d*) The Farmers with Better Breeds of Sheep and Cattle.

ROBERT BAKEWELL (1725–1795).
THOMAS WILLIAM COKE (1752–1842).

The new ways of farming made it possible not only to grow larger and better crops, but also to rear better sheep and cattle. Now that turnips and mangels could be grown for winter food, there was no need to kill so many animals in the autumn. The enclosed fields made it easier for a good farmer to keep his stock clean and healthy.

With an increasing population, more animals were wanted for food. In the old days sheep had been kept for wool rather than for mutton. They were long-legged and bony, with "skin rattling on their ribs like skeletons covered with parchment." The bullocks were as bony and long-legged as the sheep, for they were used to drag carts through muddy tracks, and ploughs through heavy soil. Even in summer they were never even moderately fat; in winter they were half-starved.

A Leicestershire farmer, Robert Bakewell, set himself to improve his sheep. Before the death of his father made him master of the family estate at Dishley, Robert had visited farms in all parts of the country; and the knowledge thus acquired he put to practical use at Dishley.

Bakewell's farm was soon famous for sheep. His "new Leicestershires" became known all over England, and in America, and many parts of Europe, too. These sheep were small-boned, short-legged, and well covered with flesh. It is said that sheep sent to market in 1800 were three times as heavy as the sheep had been a hundred years before.

Bakewell also improved his cattle and horses, producing a new and very useful type of farm horse.

Other farmers followed Bakewell's example, till England became, and still is, the country to which buyers come from all parts of the world to buy various breeds of horses and cattle, pigs and sheep.

Thomas William Coke, Squire of Holkham, in Norfolk, was another of the "new farmers." He was only twenty-two when he succeeded to his father's estates. The land around Holkham was poor and neglected, but the young squire got the best advice, and soon wheat was being grown on his farms, and the breed of cattle, sheep, and pigs greatly improved.

Grass is the principal food of cattle during the greater part of the year, but Squire Coke noticed that the animals liked some kinds of grass much better than others. He picked bunches of the grasses that the cattle chose. Then he called the village children together, gave them a few lessons in botany, and sent them out to gather the seeds of the grasses he wanted. These seeds were scattered over his pastures, and in this way the grass was much improved.

By his care and patience, Squire Coke is said to have increased the value of his Holkham estate from £2,200 to £20,000 a year. He was always ready to help any of his tenants who were trying to improve their farms, and he was greatly loved and respected by all. At the annual sheep-shearing, he showed his keen interest in good farming, and his willingness to teach and to learn, by sitting down to lunch with six hundred farming friends. In 1837, Squire Coke was made Earl of Leicester, a title held by his grandmother's family.

Other improvements were made in draining the land and making better machines, and even making better soil by mixing chalk and clay with the sandy soil in such counties as Norfolk. Indeed, we of the present day owe

a great debt to the patience and perseverance of the "new farmers" of the eighteenth century.

Questions.

1. How were ploughing, sowing, reaping, and threshing done in the eighteenth century? Illustrate your answer with drawings.
2. What changes are there in the above methods to-day? Find pictures to illustrate the differences.
3. How did Jethro Tull improve the system of sowing and hoeing?
4. What is meant by the expression, "rotation of crops"? What is the "Norfolk rotation"?
5. Mention two Norfolk farmers who did a great deal for agriculture. What improvements did they effect?
6. Why were fields enclosed? What were the advantages, and also the disadvantages, of land enclosure?
7. What did Robert Bakewell do for farming?

2. HEROES OF THE LANCASHIRE COTTON INDUSTRY.

(*a*) Early Days of the Cotton Industry in England.

The manufacture of cotton goods was begun in England at the end of the sixteenth century by refugees from Antwerp. As it was a new industry, foreigners were allowed to practise it, and it was free from the rules and restrictions that governed the woollen trade.

In 1641, cotton spinning and weaving were started in Manchester, an unchartered town, free from rules imposed on even small towns that possessed charters. The making of cotton fabrics was at this time largely a cottage industry. A spinning wheel, or a loom, or both, stood in nearly every cottage. Some of the time that the cottagers could spare from the land was spent in spinning yarn at the wheel, or weaving at the loom. But the cloth thus woven was coarse in texture.

Then began a series of inventions that brought the old cottage industry to an end, and led to the building of the big cotton mills. These inventions were, with the exception of the "flying shuttle" and "cotton gin," first used in cotton manufacture and later in the woollen industry.

A Spinning wheel of the time of Arkwright.
Courtesy of Science Museum.

(*b*) John Kay and the "Flying Shuttle" (1704–?1764).

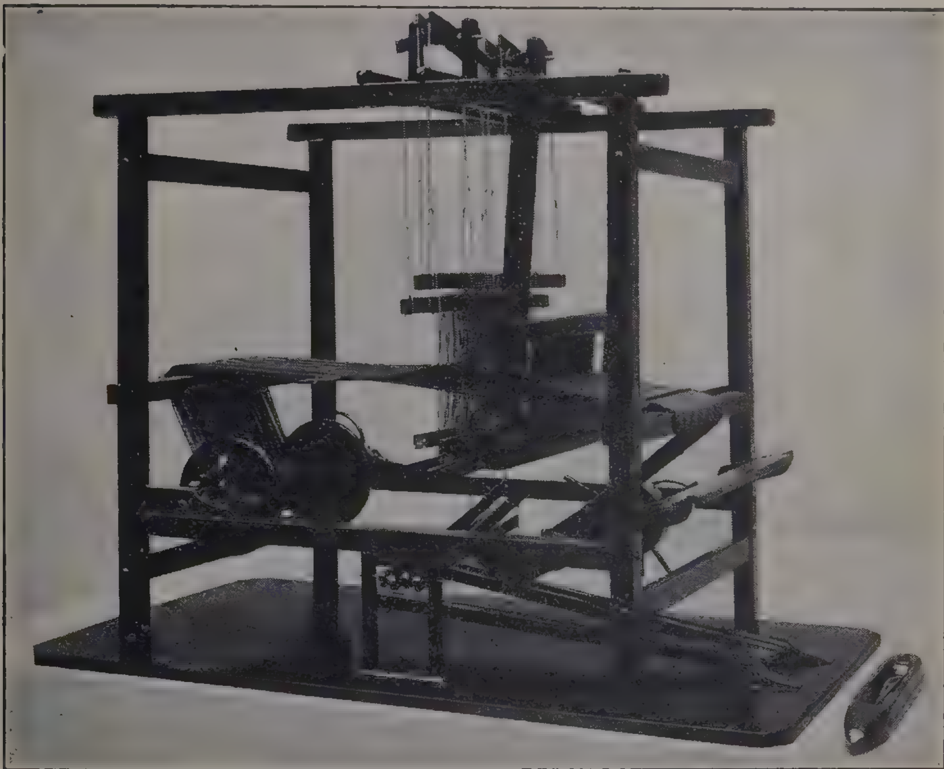
The first of these inventions was that of the "flying shuttle." It was patented in 1733 by John Kay, a native of Walmersley, near Bury, but then living at Colchester.

Up to that time, the shuttle that carried the woof thread between the warp threads had been thrown by the weaver's hand from side to side. In weaving wide cloth two men were required at the loom, one on either side, and they passed the shuttle backward and forward.

By Kay's invention the weaver merely pulled a string, and the shuttle went flying on its way through the web. This made it possible for one man to work a wide loom: and it was also a healthier way of working, as the weaver could sit upright instead of having to lean forward. On

the other hand, this way of working needed more strength than the old double loom, which was still used by older workers.

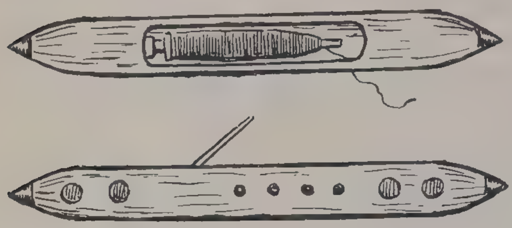
The weavers of Colchester gave the invention a very poor welcome; and their fear that his machines would



A Model of a Hand-loom. *Courtesy of Science Museum*

rob them of employment drove Kay to the north of England, where he settled at Leeds. Here he found the "clothiers" (as the weavers of woollen cloth were then called) quite ready to use his invention, but not to pay for its use. When Kay brought lawsuits against them in defence of his rights, they formed a "Shuttle Club"

to pay their fines. In the end their mean, dishonest conduct drove him from Leeds, and he went to Bury.



The "Flying Shuttle."

In spite of disappointment and poverty, Kay carried on his work of invention, and made improvements in the way of spinning. When this became known, in the year 1753, a Bury mob broke into his house, smashed everything it could lay hands on, and would have killed the inventor, had not two friends carried him, wrapped in a woollen sheet, to a place of safety.

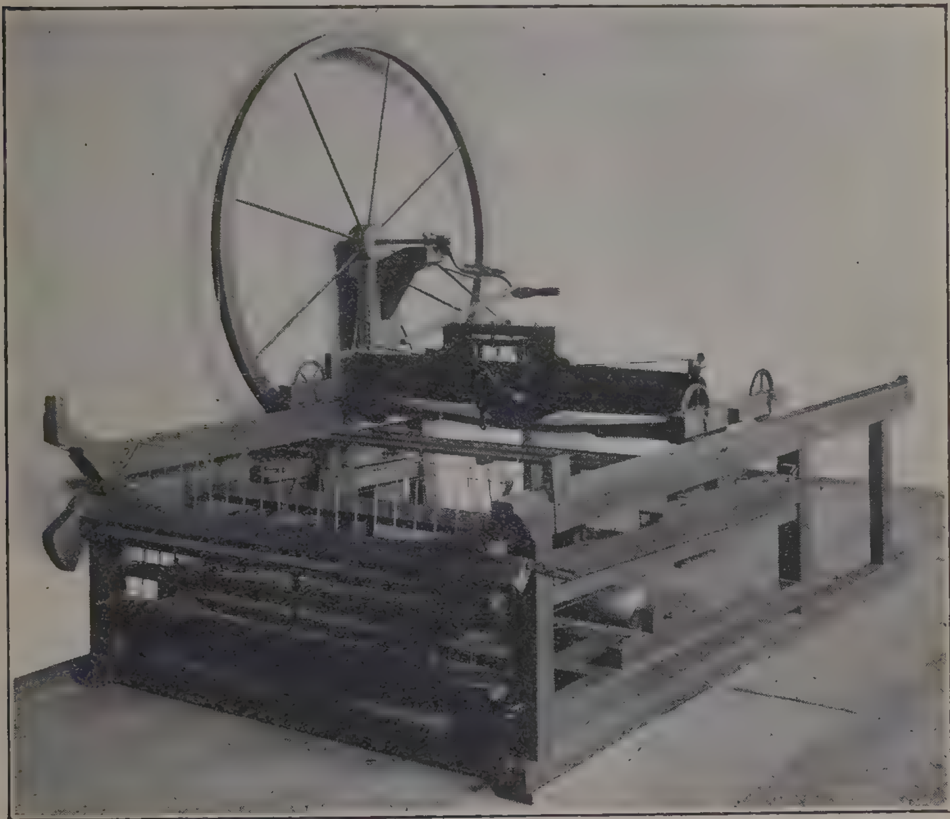
A Hand-loom Weaver at work.

Kay tried to get help from the Government, but failed. He left England, and is said to have died in great poverty in France. In a letter to a friend, he declared that he had devised many other inventions, but had not brought them to public notice, because of the bad treatment he had received.

His son Robert invented what is known as the "drop-box," which enables the weaver to use a number of shuttles, each containing a differently coloured weft.

(c) James Hargreaves and the "Spinning Jenny." (Died 1778.)

By 1760, the "flying shuttle" was in general use in cotton weaving, and the weavers used the yarn more quickly than the spinners could spin it. Much time was wasted by the weavers in collecting yarn, and waiting for



Replica of Hargreaves's Spinning Jenny.

Courtesy of Science Museum.

fresh supplies. Then came the first of the inventions for spinning by machinery.

The story goes that James Hargreaves, a weaver of Standhill, near Blackburn, came suddenly into the kitchen where his wife was spinning. She was startled by the

sudden entrance, and overturned her wheel. As it lay on the floor, Hargreaves noticed that both the wheel and the spindle went on revolving. The idea came to him that if a number of spindles were placed upright and side by side, several threads might be spun at the same time.

Sir Richard Arkwright.
National Portrait Gallery.

This lucky idea was worked out, and in 1767 the first spinning machine was produced. The machine was called the "Spinning Jenny," because it did a woman's work; or it may have been named after Mrs. Hargreaves.

Hargreaves meant to keep the secret of his invention in his own family. He knew its value, but feared the jealousy of his neighbours; and so he used the "jenny" to provide yarn for his own loom. The secret soon leaked out, and an angry mob of spinners, who thought the new invention would rob them of their bread, broke into the house and wrecked the machine.

Soon after this Hargreaves left Blackburn and settled in Nottingham. In 1770, he took out a patent for his "jenny," but, in a subsequent lawsuit, it was held to have no legal standing, because he had sold six "jennies" before he left Lancashire, in order to buy clothes for his large family of children. So Hargreaves could claim nothing from the spinners who were using his machines.

He managed, however, to scrape together enough money to start a small factory. Although never a rich man, he was able to leave his wife and family fairly well off when he died in 1778.

(*d*) RICHARD ARKWRIGHT and his Spinning Frame (1732–1792).

Richard Arkwright, one of the great "captains of industry" in this country, was born at Preston in 1732, the youngest of a family of thirteen. His parents were too poor to give him any schooling to speak of, and he was soon sent out to earn his bread. He served an apprenticeship to a barber in his native town, and, about 1750, moved to Bolton, where he set up in business for himself.

Arkwright knew nothing about machinery or spinning, but he was quick-witted, with a great desire to find out as much as possible. He often heard his customers grumbling about the shortage of yarn, and he saw that a fortune might be made by one who could devise a speedier method of spinning. His own business was not paying very well. Wigs were going out of fashion, and wig-making was an important part of a barber's business; so Arkwright decided to set to work on a spinning machine.

He employed a clock-maker, named Kay,* to make some of his apparatus. Kay was a friend of Thomas Highs (or Hayes), a reed-maker† of Leigh, who was engaged on experiments of the same kind. It was afterwards said that Arkwright used Kay to get valuable hints from Highs for him, but this has not been proved. Even if he did owe something to Highs, it is certain that Arkwright was the one who made a machine that *would work*.

* Not Kay of the "Flying Shuttle."

† A "reed" is an appliance used for separating the threads of the warp, and for beating the weft up in the web

But Arkwright was himself too poor to carry on his experiments. It is said that, on the occasion of a "great election," he was in such a tattered condition that his friends made a collection in order that he should appear in a decent condition at the poll-room.

Arkwright's wife had no sympathy with her husband's ideas, and, feeling sure that he would starve his family by scheming when he ought to be shaving, she smashed some of his models. As a result, the two separated.

Then Arkwright found a friend, a certain Mr. John Smalley, who was willing to provide money for carrying on the experiments. The model machine was set up in the parlour of the house owned by the headmaster of the Preston Free Grammar School, and here the ex-barber carried on his work for a time. His secret task was looked upon as very suspicious, and he was even accused of witchcraft, for two old women declared that they had heard strange humming noises, "as if the Evil One were playing his bagpipes."

Then news reached Preston of the riot caused at Blackburn by Hargreaves's "spinning jenny." Fearing the machine-breakers would find out what *he* was doing, Arkwright, accompanied by his friend Smalley, moved to Nottingham, where they entered into partnership with two manufacturers, Mr. Samuel Need and Mr. Jedediah Strutt, who were able to help with business experience as well as money.

In 1769, Arkwright took out a patent for his "spinning frame." It was better than the "jenny," for the threads it spun were fine but tough, and could be used for warp, while the "jenny" threads were only strong enough for weft. Arkwright then set up his first spinning mill, where the machine was worked by horses. Two years later, with the help of Messrs. Need and Strutt, he built

a much larger mill at Cromford, in Derbyshire, where the machinery was worked by a water-wheel.

Arkwright took out a fresh patent in 1775, and made many further improvements in preparing and spinning yarn. He had several mills in Derbyshire and Lancashire, and in 1790 he had one of the new steam-engines set up in his mill at Nottingham.

Arkwright's Original Spinning Frame, 1769.
Courtesy of Science Museum.

But Arkwright had many difficulties to face. The spinners hated the new machines, thinking they were robbing them of their livelihood. In 1779, in an outburst of fury, they destroyed his mill at Chorley. Rival mill-owners, too, were jealous, and refused to buy his yarn, although it was of better quality.

Many mill-owners copied his machines, and set them up in their mills without his permission. In 1785, Arkwright brought a lawsuit against one of the offending mill-owners, and won his case. But, in a second trial,

Highs and Kay were brought forward to give evidence that Arkwright did not really invent the machine which was patented in his name; and, as a result of this, his letters patent were cancelled.

After the trial, it is said, Arkwright overheard one of his rivals say, "Well, we've done the old shaver at last!" To this the ex-barber replied, "I'll find a razor in Scotland to shave you all with yet." This story may not be true, but it is a fact that, not long afterwards, Arkwright did set up mills in Lanarkshire.

Arkwright was a very hard-working man, busy from early morning till late at night. When the work in connection with his many great mills was done, he tried to make up for his lack of schooling by learning writing, spelling, and grammar. When he travelled from one mill to another, he was driven by four horses at great speed, so that as little time as possible might be wasted on the journey.

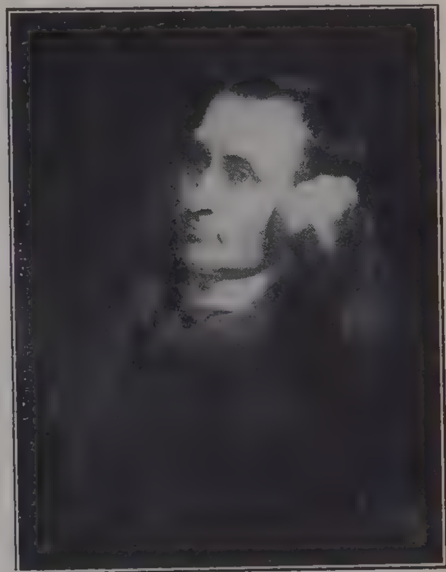
Richard Arkwright was knighted by George III in 1786. He died at Cromford in 1792.

(*e*) SAMUEL CROMPTON and the "Mule" (1753–1827).

A less fortunate hero in the story of cotton was Samuel Crompton. He was an only son, well educated, but shy and nervous. At the age of sixteen he was earning his living by spinning upon one of Hargreaves's "jennies," and before he was twenty-one he was beginning to work out improvements. He was living at the time in a half-ruined old house, Hall-in-the-Wood, near Bolton. He knew very little about machinery, and had to earn money for tools by playing the violin in Bolton theatre. After five years of hard work he made a machine which he called the "mule."* It was able to spin a much

*Compare the pictures on pages 22 and 99.

finer thread than the other machines. Crompton did his work under difficulties. Once when he was at work on the "mule," he heard the shouts of rioters who were destroying a building in a neighbouring hamlet where there was a carding machine.* Fearing they would come to his house and destroy his "mule," he took the machine to pieces, put it in a basket, and hoisted it through the ceiling into the attic by a trap-door he had made in case of an attack.



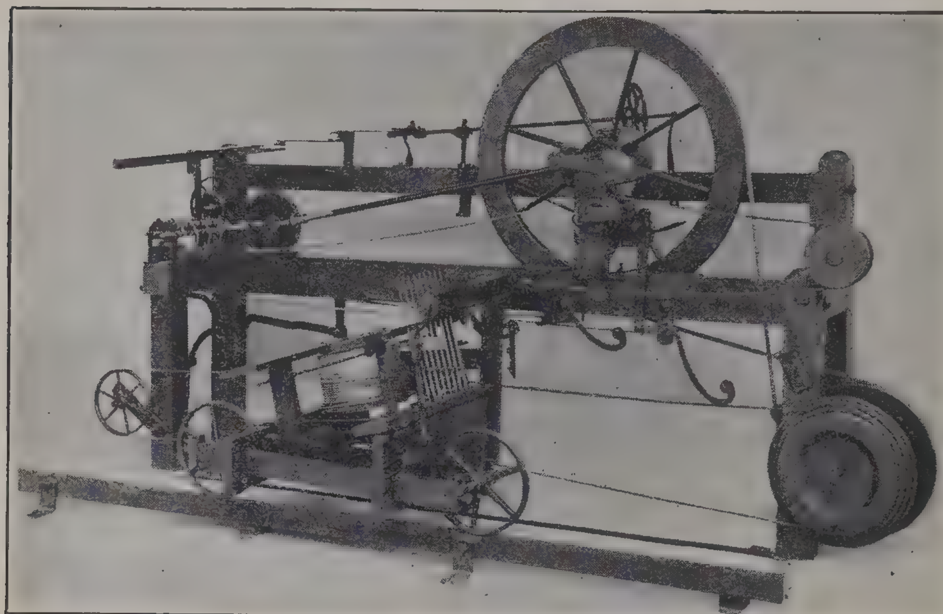
Samuel Crompton.
Photo. : W. F. Mansell.

When the machine was really finished, Crompton would have been quite content to enjoy his own invention, and the better price he could get for his yarn, for he had no money to spend on taking out a patent. But as soon as it was whispered that he had found a way to spin finer yarn, he had no peace. People came from miles around, and climbed up at the windows to see him at work. He put up a screen, but even then the annoyance was too great for him to do his work properly.

At last he promised to give up his machine, if the manufacturers paid him for it. He expected to get a very large sum of money, but all he actually got was £60. When he called on the manufacturers to ask for the subscriptions they had promised, many of them drove him rudely from their doors, and refused to pay.

* A carding machine is used for combing out the fibres of wool, cotton, etc., and removing impurities, such as bits of pod, thorns, and grit.

Crompton's "mule" spun such a fine thread that, when it was set up in the mills, Lancashire weavers were able to make fine muslins such as had, up to that time, been brought to this country from India. But Crompton

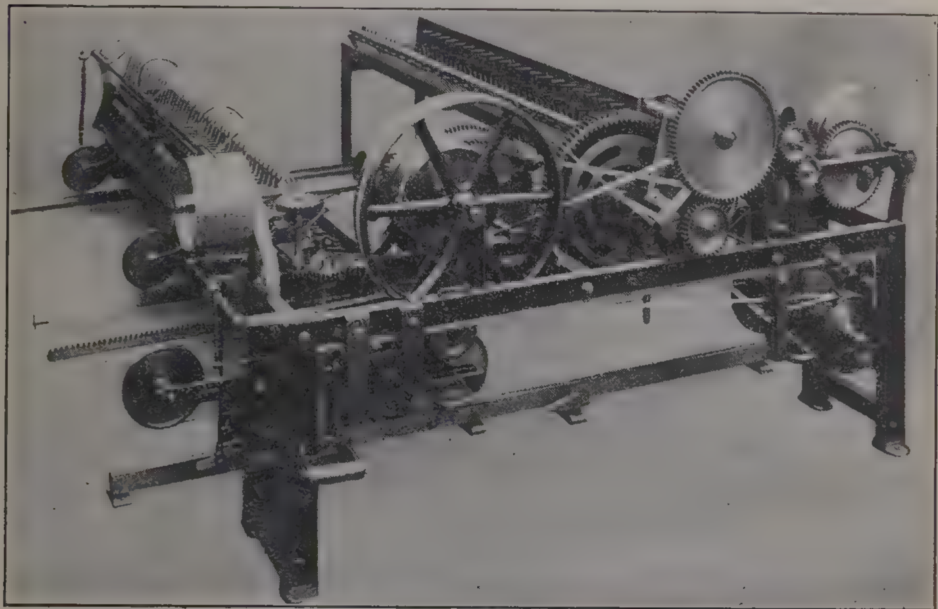


Replica of Crompton's Mule. *Courtesy of Science Museum.*

was so discouraged to see the fortunes made by his machine for which he had been paid so little, that he gave up trying to invent.

Thirty years later, some of Crompton's friends sent a petition to Parliament, asking for some reward for the inventor. Mr. Perceval, the Chancellor of the Exchequer, was very much in favour of the reward. One day in May, 1812, Crompton was in the lobby of the House of Commons with some friends. Mr. Perceval came to them, and said, "You will be glad to hear that we mean to propose £20,000 for Mr. Crompton. Is that enough?"

Crompton politely moved away; but he was delighted to think he was to receive a reward at last. While he waited for his friends, he heard a great commotion, and was told that Mr. Perceval had been shot by a madman.



A Self-acting Mule, from a model in the *Science Museum*. Compare this with the illustration on page 99.

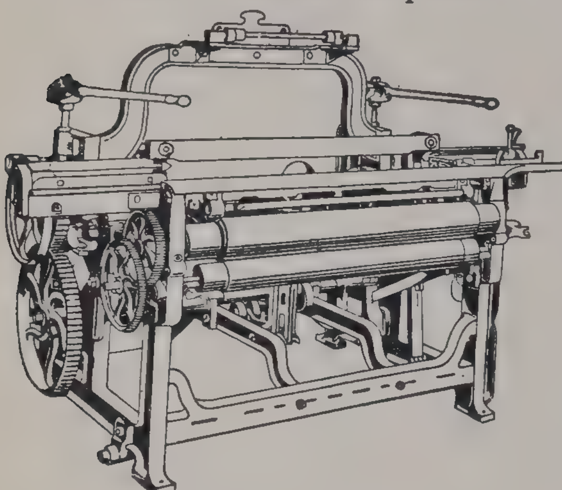
Instead of £20,000, Crompton received £5,000, although it was proved that 5,000,000 " mule " spindles were giving work to 70,000 spinners, and indirectly helping 150,000 weavers.

It is interesting to know that Crompton's old house at Hall-in-the-Wood is now kept, in his memory, as a museum in which may be seen examples of all this early cotton machinery.

(*f*) EDMUND CARTWRIGHT and the Power Loom (1743–1823).

As we have seen, spinning machines were first driven by hand, then by a horse gin, then by water-power,

and, at last, by steam. But, for a time, weaving continued to be done by hand. Then the first power loom was made by a clergyman, Edmund Cartwright. After a visit to one of Arkwright's mills, Mr. Cartwright said he believed it would be possible for a machine to be made to weave. His friends laughed at him, but he got a carpenter and a smith to help him, and in 1784 he set up a power loom at his rectory at Goadby Marwood, in Leicestershire. It was a heavy, clumsy affair, and required two strong men to work it. But the inventor made improvements, and the next year he took out a patent. The improved machine was worked by a bull.



A Modern Power-loom.

About this time Cartwright went to live at Doncaster, where he set up a small spinning and weaving mill. A Manchester firm was attracted by the power loom, and offered to build a factory large enough for 500 looms. They set up a few looms as a test, and found that they worked well, doing the work at half the cost of hand-weaving. Hearing of this success, the hand-weavers wrote threatening letters, and at last set fire to the mill, destroying both the building and the machines. For a time other mill-owners were afraid to set up power looms, and as the Doncaster factory did not pay, Cartwright became bankrupt.

But, in spite of the jealousy of the hand-weavers, power looms gradually came into use, driven first by

water-power, then by steam. In 1813, there were 2,400 power looms in use in England, and twenty years later there were 100,000.

Cartwright fared better than many inventors, for he received a reward of £10,000 from Parliament in 1809. He spent his later years at his farm near Sevenoaks, in Kent, where he amused himself by inventing agricultural machines. Besides the power loom for the cotton weavers, Cartwright invented a combing machine for the woollen workers, which was of very great help in preparing the woollen yarn.

(*g*) Eli Whitney and the Cotton Gin (1765–1825).

With all the new inventions more and more cotton goods were made ; but towards the end of the eighteenth century there was a scarcity of raw cotton. Most of the cotton at that time came from the West Indies, and from Smyrna and Turkey. The United States, from which most of our cotton comes to-day, could not grow long-fibred cotton. Their cotton had short fibres, sticking closely to the seeds. The cotton growers did not know how to separate the seeds quickly and easily, and until they could do so they could not sell their cotton.

About this time, a young man, named Eli Whitney, left his home in Massachusetts to take a post as a schoolmaster in South Carolina.

Whitney had always been fond of tools and machinery ; even when he was a boy, he could mend violins, make nails, and do many ingenious things with simple tools. One Sunday, while his parents were at church, he took his father's watch to pieces, and then put it together again so well that his father did not know it had been touched.

Then he went to college, and made up his mind to

be a schoolmaster. He went to South Carolina to teach, but he found the salary was so small that he could not live on it.

On the boat going south Whitney had met a rich widow, named Mrs. Greene, who was very kind to him, inviting him to stay at her house. There the young man met many of Mrs. Greene's neighbours, who were cotton planters. These men were all anxious to grow more cotton, but they said there was no profit on the crop, because it cost so much to take the seeds from the lint.* The work was done by slaves; and it took ten hours to take three pounds of seeds from one pound of lint.

" You ought to have a machine to do the work," said Mrs. Greene. " This young man shall make one. He is very clever, for he has mended everything that wanted mending in my house."

She gave Whitney a room in the basement of her beautiful house, and he set to work. He tried many plans, but found the seeds clung so tightly that he wondered how anyone could have the patience to pick them out.

At last he tried the plan of pushing the lint through slits so narrow that the seeds were broken off; but then the lint piled up and got in the way.

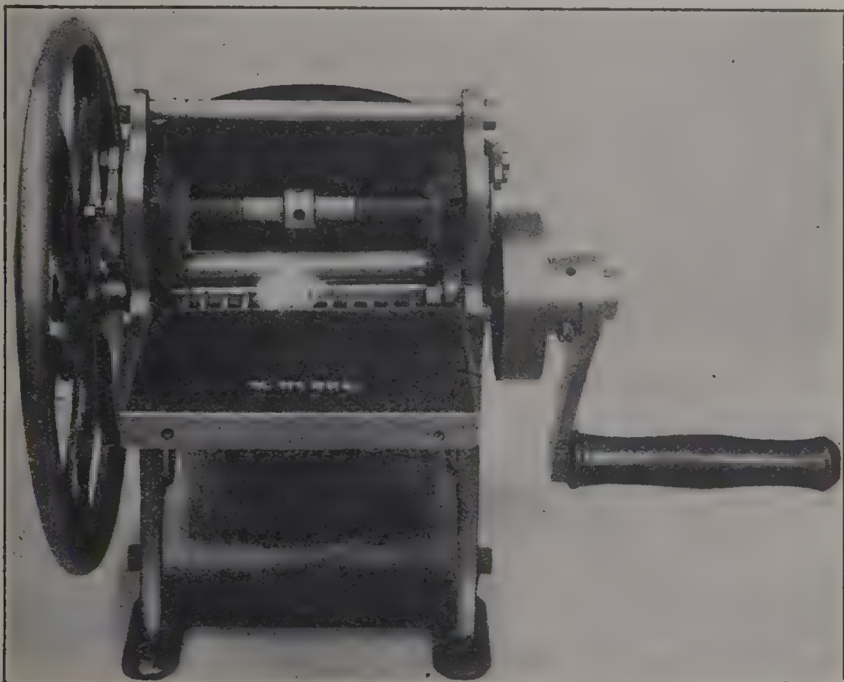
" You want a brush to clear it away," said Mrs. Greene, and she offered him the one she used on her hearth.

Whitney took the hint, and fixed a brush that turned round and round, sweeping the cotton into a box. Little by little he overcame difficulties, and in a few months he had a model gin (i.e. engine) which he turned by hand, and which successfully cleared the seeds from the cotton.

Mrs. Greene and her friends were delighted, and

* In the Southern States, the term used for the fibre of cotton.

they begged Whitney to patent his invention. With their help this was done in 1794. But, like many other inventors, Whitney made little profit out of his idea. Dishonest people copied his machine and sold their copies, without paying the inventor his just profit.



A Cotton Gin. *Courtesy of Science Museum.*

Whitney's invention supplied just the thing needed by the American cotton growers. More planters were able to grow cotton, and as Liverpool was the port that was most convenient for the Atlantic ships, and also close to the cotton mills, it soon became a very important town. Lancashire has a damp climate just right for cotton spinning. In the early days it had plenty of water for the mill wheels, and when steam took the place of water, Lancashire, having coalfields, still held its place.

So in seventy years (1730 to 1800) the series of inventions, beginning with the "flying shuttle" and ending with Whitney's cotton gin, completely changed the cotton industry.

In this chapter we have only been able to speak of the *great* inventions; but there were countless other smaller inventions that improved and adapted machinery, and made it the power it is to-day.

All these changes did not happen without bringing hardship to many of the hand-spinners and hand-weavers, for they could not work so well or so cheaply as the machines. Often they were forced to leave their cottages, and go to work in the new factory towns. But that is another story.

Questions.

1. Why did the cotton trade develop in Lancashire, and the woollen industry in Yorkshire? Find out the early history of the latter.

2. What obstacles did the various inventors of the new machinery in these industries have to face? Why did some people dislike the machinery?

3. Make notes on the new inventions and their inventors, in order of time. Give dates, and make drawings to illustrate the inventions.

4. Draw in your notebooks a spinning wheel and a hand-loom of olden times. Also find pictures of the interior of modern spinning and weaving mills to paste in your books for comparison.

5. (*For girls.*) Write out a list of the various materials made from cotton to-day, with a brief note on each. State, in every case, the usual price per yard.

6. What other processes are necessary in cotton manufacture besides spinning and weaving?

7. Are spinning and weaving done to-day by hand? If so, where?

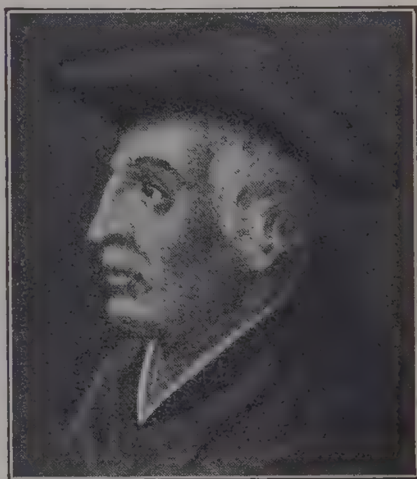
8. Obtain from the library Charlotte Brontë's novel, *Shirley*. Prepare selections from Chapter 2 having reference to the new machinery, and read them to the class.

9. How did the introduction of the new machinery affect employment and the distribution of population?

3. PIONEERS OF STEAM POWER.

(*a*) Dreaming of Steam.

Although it was not until the eighteenth century that men were able to make steam-power do really useful work, the idea was not new. For centuries clever men had been dreaming of using this strange power, but they could not find out how to do so. Hero of Alexandria, a Greek who lived in the third century before Christ, left a book in which he spoke of using steam to open temple doors, and to do other things, in a way that would seem magical. His book was discovered during the fifteenth century, translated, and printed in several languages. It set many men thinking hard about the power of steam.



Roger Bacon, after the picture in the collection at Knole.
Rischgitz.

Friar Roger Bacon, who lived at Oxford during the thirteenth century, had declared that the day would come when carriages would move rapidly along, all by themselves, and boats would move without oars or sails; but people thought this kind of talk savoured of sorcery and of a league with the powers of darkness, and Bacon was kept in prison for many years, and not allowed parchment until the Pope came to his help and told him to write a book on his ideas.

The oldest picture of a steam-engine is probably that printed in an Italian book about three hundred years ago. It shows an iron figure, shaped like the head and shoulders of a man, fixed over a fire. The figure was really a

boiler which could be filled with water through a hole in the top of the head. As the water became heated by the fire, it began to turn into steam.

Steam takes up more room than water, and it wanted to get out of the boiler. The only place from which it could escape was a tube held in the mouth of the figure. As the steam shot out of this tube, it blew against a wheel, and made it turn round. This wheel turned a smaller one above. Then a third wheel, with little cogs, began to turn, and this made two rods go up and down. The rods had heavy club-like crushers at their lower ends, and no doubt these were used for crushing grain or some other article placed beneath in jars. We do not know who made this very old steam-engine, or what it was really used for, but it shows that the dreamers were beginning to put their ideas into shape.

(*b*) A French Pioneer.

About 250 years ago there lived in France a young man named Denis Papin. He was born in the ancient French city of Blois, where his father practised as a physician. When he was about fifteen, he himself entered upon the study of medicine; and, after having passed his examinations, he set up as a doctor. He did not like the work, however; he wanted to make machines.

At this time the idea of making steam *do work* was much talked of all over Western Europe. A clever Irishman, named Robert Boyle, was making experiments in London. Papin crossed to England, and, joining Boyle as an assistant, he soon proved that he was an ingenious inventor.

After spending three happy years in England, Papin was asked to go to Venice, where some similar experiments were being made. He went, but was very much

disappointed to find none of the great chances he had looked for. In 1684, he came back to England, and was given a small scientific appointment with the Royal Society, enabling him to carry on various investigations. He made, for example, a model of an engine for raising water from a river by means of pumps.

Then Papin was offered a post at a university in Germany, and he gladly accepted the offer, hoping to devote his spare time to his work on steam-engines. He wanted to make an engine that would move a boat without the aid of oars or sails. For fifteen years he worked on his idea, and at last he made a little steamboat.

He had this conveyed to the River Weser, but was told that he must not attempt to run it. He went on board, however, and the engine was started. This was scarcely done when boatmen boarded the vessel, and took the engine to pieces. They feared this new kind of boat. Perhaps they thought that the boiler would explode, or that the steamboat would run into their own vessels and wreck them.

Papin was bitterly disappointed. He left Germany and came to London, but he was penniless and friendless. After a while he went back to his old home in France, where he died a few years later, probably about 1712, in great obscurity.

But he possesses a distinct place in the record of human progress, as being one of the inventors of the steam-engine.

(*c*) Thomas Newcomen and his Engine (1663–1729).

While Papin was working at his steamboat, a Devonshire gentleman, Thomas Savery, made the first steam-engine that was really able to do useful work. It was called the "Miners' Friend," and was used to raise

water from wells or mines. The plan was that the water to be drained off or raised was sucked into a vacuum (that is, a space emptied of air), and then forced out by steam.

This engine worked very well for raising water from wells, or feeding fountains in gentlemen's gardens; but when it was used in Staffordshire for pumping water from mines, it proved a failure. The truth was that the metal used for the boilers and parts of the engine was not strong enough to stand the pressure of a large volume of water. Before steam-engines could be really successful, the iron workers had to make better and stronger material.

Then a neighbour of Savery's, Thomas Newcomen, a blacksmith and ironmonger of Dartmouth, made a much better engine, which pumped up the water by an ordinary pump worked by an engine.

This pump was connected by a lever beam with a piston which moved up and down in a cylinder. The piston went up, because it was pulled by a weight fixed to the other side of the beam; it went down, because it was sucked into a vacuum in the cylinder. This vacuum was made by filling the cylinder with steam, and then cooling the steam with a dose of cold water to make it condense. As the steam condensed, it took up less room and the vacuum was made.

Newcomen's first engine was able to lift fifty gallons of water fifty yards at each stroke, and it could make twelve strokes a minute.

At first Newcomen condensed the steam by throwing cold water on the outside of the cylinder, but, one day, he noticed that the engine was suddenly running faster. He found that a hole had been worn in the cylinder, and that the water with which he had covered the top of the

cylinder to make it air-tight was entering through the hole. The water was condensing the steam much more quickly than it did from outside. In his next engine he used a jet of water to save time.

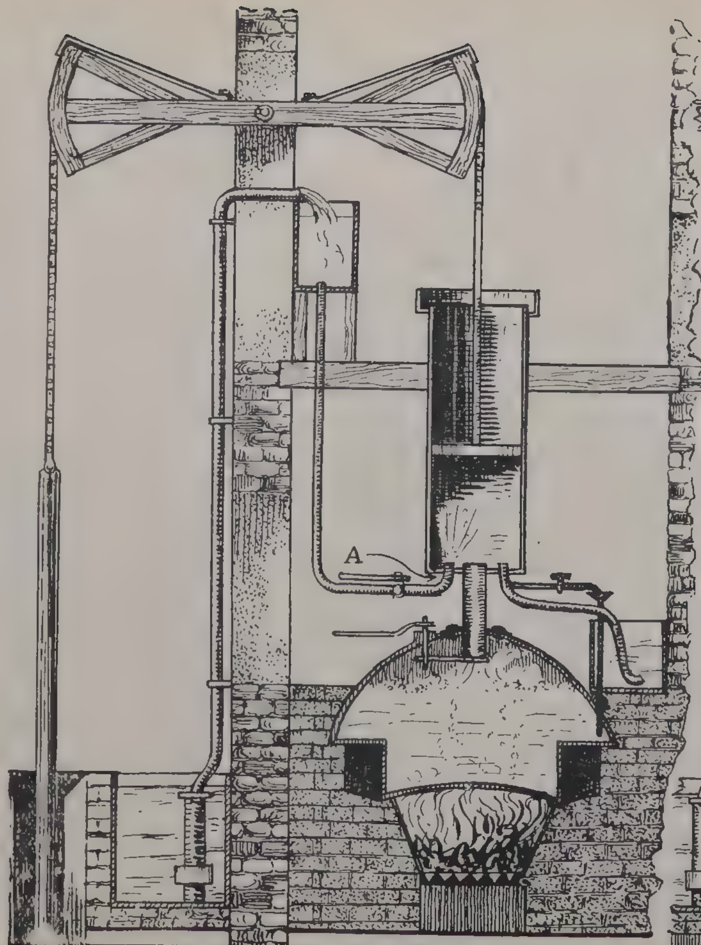
The alternate doses of steam and water were managed by turning taps by hand to let first the steam, and then the water, into the cylinder. It is said that an improvement was accidentally made by a boy named Humphrey Potter. The story goes that Humphrey found his work of turning taps hour after hour very tiresome, so he tied strings from the taps to the lever, and so made the engine itself turn the taps. This lazy boy's idea led, it is said, to what is known as the valve gear.

Newcomen's engines were a great help in many coal mines in England and Scotland, because, as mines are dug deeper into the earth, the water gets in from the soil around, and in time the mines become flooded. But many smaller mines found the engines too expensive to keep working. The largest engine used many tons of coal in a year. Most of this fuel was needed for the re-heating of the cylinder, after it had been cooled ; in fact four-fifths of the steam was spent in making the cylinder hot enough for the remaining fifth to do its work.

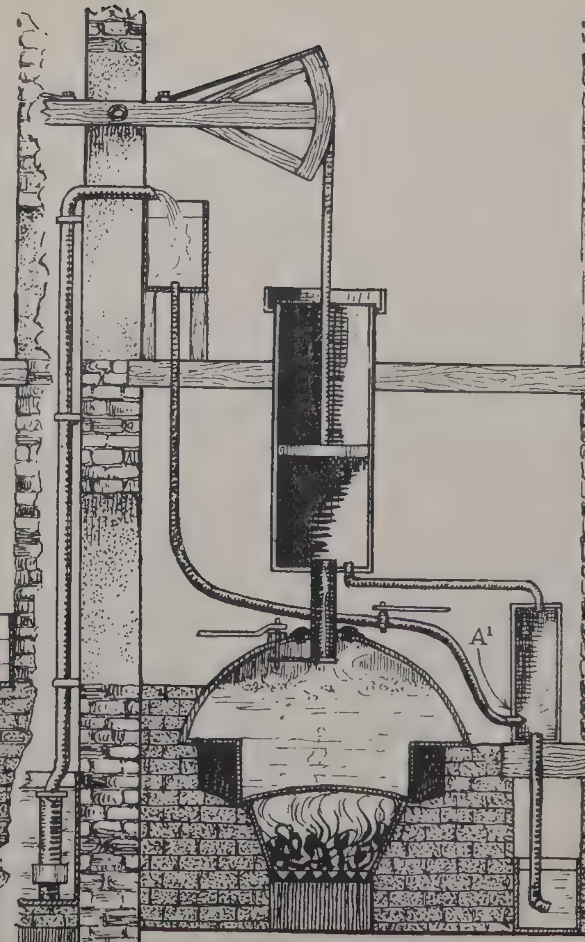
The problem amounted to this—how could a cylinder be both hot and cold at the same time ? This question was answered by James Watt.

(*d*) James Watt (1736–1819). Matthew Boulton (1728–1809).

James Watt was born at Greenock. He was a dreamy boy, fond of drawing, with very little to say, but always eager to find out things for himself. When he was eighteen, he wanted to learn how to make the mathematical instruments used by clever people in making



Newcomen's Engine. *A*—the jet of water which entered the cylinder and caused the steam to condense.



Newcomen's Engine with Watt's improvement. A^1—the water causing the steam to condense without cooling the cylinder of the engine.

scientific tests and drawings. He went to Glasgow, but found that there was no one there who could teach him this trade. Then he went to London.

The instrument makers in London, as Watt found, wanted him to serve an apprenticeship for seven years. His parents were poor, and the lad felt he must not wait so long as that before he began to earn his own living. Then he found an instrument maker in Cornhill, who, for the sum of twenty guineas, was willing to take him into his workshop, and teach him the trade in twelve months.

Just as Watt had settled down to his work, the Seven Years' War (1756-63) broke out. Press gangs were busy in London, seizing young men and forcing them to serve in the navy. Apprentices and "creditable tradesmen," if seized, were taken before the Mayor, and released on proving their position, but as Watt was neither an apprentice nor a tradesman, he would not have been able to get off. In order to keep clear of the press gangs, he stayed indoors all the time, and this injured his health.

At the end of the year, Watt returned to Glasgow. Knowing that there was no instrument maker working there, he hoped to set up in business for himself and do well. But Glasgow was a chartered town, and the guild of hammermen objected to Watt setting up shop, because he was not the son of a burgess, and had not served an apprenticeship in the borough. The Corporation, therefore, refused to let him set up in business. He had, however, done some work for the professors at the University, and they came to his help by appointing him instrument-maker to the University at £35 a year.

His work was to make models of machines that the professors wanted to show to their pupils, and to repair any models that needed it. In this way he began to

study the steam-engine. There was a model of one of Newcomen's engines at the University, and one day it was sent to Watt to be mended. He did what he could to the little engine, but as he worked he wondered if there might not be a better way of managing the steam.

One Sunday afternoon in 1765, Watt was walking on Glasgow Green. He was still puzzling over the engine. The question which he was trying to answer was how could the steam be condensed without at the same time cooling the cylinder.

Suddenly he found the solution of the difficulty. If a pipe were placed between the cylinder and a vessel emptied of air, the steam would rush into the vessel, and it might there be condensed without cooling the cylinder. This idea of having a separate condenser made it possible to use steam as the power for driving machinery.

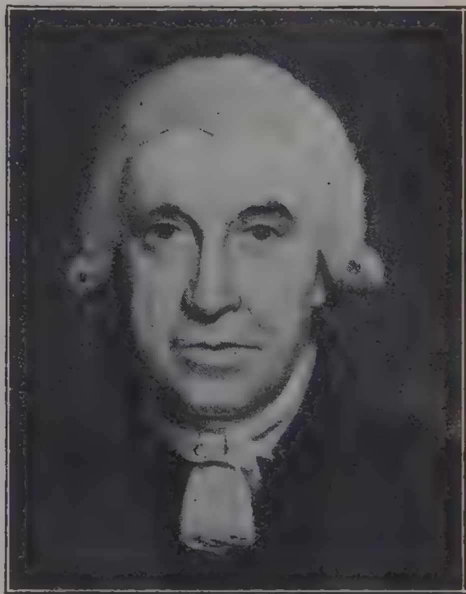
Watt told his wife of his idea, and she encouraged him to test it. He set to work on a model engine with a separate condenser, and while on with the work made many other improvements. But he had no money for making a large engine; that would have needed hundreds of pounds. In 1768, he received an offer of help from Dr. John Roebuck, of Birmingham, who was developing the famous Carron Ironworks in Stirlingshire.

The following year Watt took out a patent for his engine, and set up one as a test in an outhouse behind Kinneil House, near Linlithgow, where Roebuck lived. But the test failed. The machinery was clumsy; the cylinder was badly made; the piston was not air-tight; and, in short, the engine would not work.

Roebuck, whose mines were rapidly filling with water, could not afford to waste more money on what seemed a useless idea; so Watt gave up inventing, and for the next six years he worked as a surveyor, and made plans

for canals that were being cut in Scotland. He hated this work, but had to earn a living in some way.

In 1773, another friend saved the invention, and by his pluck and wisdom helped to make Watt's idea of real use. This friend was Matthew Boulton, a hardware merchant, of Birmingham. Boulton was the son of a wealthy manufacturer, and had shown his skill at the age of seventeen by inventing an inlaid steel buckle that caught the fancy of fashionable people. France had always been the source of this kind of ornament, so Boulton sent his buckles to France in order to bring them back to England as novelties from Paris.



James Watt.
National Portrait Gallery.

He had large hardware works at Soho, two miles from Birmingham, where he employed hundreds of men, women, and children, and where all kinds of things were made in metal, from statuettes copied from Greek models down to toothpicks, buckles, and buttons. At this great factory the supply of power had always been a difficulty. The grinding mill was driven by a water-wheel, but in summer the stream often ran dry; then horses had to be used, and this was expensive and unsatisfactory. Boulton saw the possibilities of using a steam-engine, so he invited Watt to send his engine to Soho.

Watt packed up the engine, sent it to Birmingham, and himself followed it a few months later. He made up

his mind that, if the engine disappointed him again, he would give up inventing, and seek work in England as a surveyor or an engineer. But the Soho workmen were more skilful than those at Carron, and a fresh test proved most hopeful. A cast-iron cylinder, made by the famous ironmaster, John Wilkinson, of Broseley, was put in, instead of the tin cylinder used at Kinneil. In 1775, Boulton and Watt entered into partnership.

Early in 1776, the first engines were sent out from the Soho Works; one went to Wilkinson's blast furnace to be used for blowing the bellows, the other went to Bloomfield Colliery, in Staffordshire, to pump water.

The next year, some engines were shipped to the Cornish mines; and by 1780 as many as forty engines had been sold to Cornwall, and twenty were already at work. Watt spent most of his time in Cornwall, while Boulton was unable to supply engines fast enough. The owners of many mines that had stopped work for lack of a satisfactory engine were eager to try the new kind. The Newcomen engine was given up, and the Watt engine took its place.

Watt made many improvements in his engines, and in time they could be used for almost any purpose, and might be placed in almost any position. In 1781, Boulton wrote to Watt, "The people of Manchester are steam-mill mad."

In 1784, Watt invented an engine to tilt hammers in iron and steel forges. In 1785, the first steam-engine to be used in a cotton mill was set up at Papplewick, in West Nottinghamshire. Between the years 1776 and 1800 Boulton and Watt had set up 289 engines, some in cotton mills, some in collieries and mines, some on canals, some in breweries.

In 1800, Boulton and Watt retired, and the business

was carried on by their sons. But the old men were still interested in their former pursuits. Boulton often "tottered down the hill to see what was afoot at Soho"; Watt, who retired to a new house near Birmingham, still had his workshop where he amused himself. Boulton died in 1809, and Watt ten years later.

(*e*) The "New Iron Age."

The introduction of steam caused many changes. Cotton mills that had been worked by water-wheels—

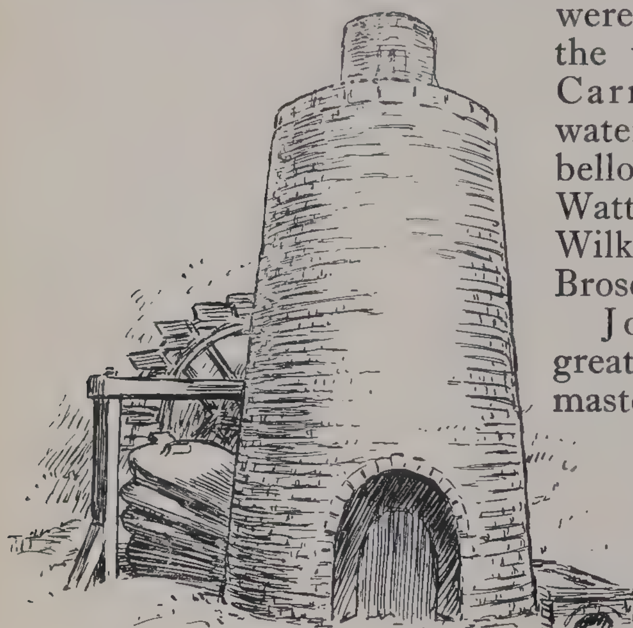
Charcoal Burning.

"beck-side mills," as they were called—were deserted, and new mills were built nearer the coal-pits.

To make the new machines and engines a large quantity of iron and steel was needed; and, accordingly, great changes took place in the iron industry. Charcoal had been used for iron smelting; and as charcoal is made by charring wood, the old ironworks were in the forest districts, such as the Sussex Weald. The old smelting furnaces, small though they were compared with modern furnaces, used a lot of charcoal. To make one load of charcoal, six loads of wood were needed, and the forests were disappearing. This was a serious thing in days when ships were built of oak.

It was a long time before men found out how to use coal instead of charcoal. In 1735, Abraham Darby, of

Coalbrookdale, in Shropshire, was successful in making iron by using coke, that is, coal from which the gases have been driven out by heating. The real difficulty was that coke requires a much bigger draught than charcoal in order to get up the same heat, and the old bellows were not strong enough for the work. In 1760, the Carron Ironworks used water-power to blow the bellows; and, in 1776, a Watt's engine was used at Wilkinson's iron furnaces at Broseley.



A Charcoal Blast Furnace

John Wilkinson, the great Staffordshire iron-master, at whose works the cylinder for the first successful Watt's engine was cast, was one of the pioneers of the "new iron age." He was called "iron-mad Wilkinson," for it is said he never wrote a letter without mentioning iron. His father made a fortune by patenting a box-iron which was of great help to laundresses in ironing the starched frills so fashionable among the dandies of the day.

Wilkinson himself set up the first blast furnace at Bilston, and so became the "father of the South Staffordshire iron industry." Besides making cannon for the war with Napoleon, he made the first iron bridge and the first iron ship, and even kept in his office an iron coffin, in which he hoped to be buried.

As steam came into use in the blast furnaces, better

iron was made, and in larger quantities. But the iron industry was transferred from the forest districts to the coalfields; and in many places iron ore and coal are found close together. The last ironworks in Sussex were closed in 1828, and Birmingham and the district near by soon came to be known as the Black Country. We know now that there is coal in Kent; so it is possible that, one day, that county may once more become a manufacturing district.

Questions.

1. Explain this statement:—"Papin dreamed of the Age of Steam, and James Watt embodied and built up the ideas borrowed from this poor neglected dreamer."

2. How was Watt's engine an improvement on Newcomen's? What problem had he solved? Make drawings to illustrate your answer.

3. What two engineers improved on Watt's engine, and in what way?

4. For what different purposes was the steam-engine first used? In what ways had the work been done previously?

5. What changes took place in the smelting of iron, and why was this industry transferred to other districts?

6. What is meant by the "New Iron Age"? Give the name of a great ironmaster connected with its development.

7. Make selections from Chapters 43 to 45 of Dickens's *Old Curiosity Shop*, having reference to the Black Country, and read them to the class.

8. Look up, and read, Kipling's poems entitled *Cold Iron*, and *The Secret of the Machines.*

4. PIONEERS OF ELECTRICITY.

(*a*) Playing with Amber: The Magic Spark.

Long, long ago the clever men of ancient Greece noticed that amber, jet, and a few similar substances, when rubbed smartly for a time, had the power of attracting little bits of straw, tiny leaves, and small feathers. They liked to play with amber, making it pick up hairs and other light fluffy bits of stuff. They puzzled about this strange power, but they did not understand it, and many centuries passed before men found out how useful that power might be.

Towards the end of the sixteenth century, during the Renaissance, men began to take a new interest in science, and found out many things that had not been known before; or if they had been known, they had been forgotten. Among other things, they began to "play" with amber once more. Like the Greeks, they were puzzled by its strange power, and determined to find out more about it. They soon discovered that glass would act in much the same way as amber, and as it was much easier to get than amber, they used it in their experiments. But they still called the magic power "electrical," from the Greek name for amber, *elektron*.

Now you can do a simple little experiment for yourself. Take a glass rod or a comb; rub it briskly for a few minutes with a silk handkerchief. You will find that it will pick up tiny bits of paper or pencil shavings. It acts like a magnet.

Soon it was discovered that the "magic power" could do more than pick up things. The glass tubes or globes, when rubbed, gave out little "shocks." A scientist, named Stephen Grey, proved this by a curious experiment. He hung a boy from the ceiling by silken

cords. He believed that the silk would not let the electricity get away, and he was quite right. Then he touched the feet of the boy with a glass tube that had been well rubbed. A shock passed through the boy's body, and was felt by a person who held his hands.

A Frenchman, named Dufay, tried the plan of hanging himself by silken loops from the ceiling, while a friend gave him the shocks by means of a glass globe. In this test the friend happened to put his finger between the globe and Dufay's leg. A spark was seen.

A seventeenth-century German, named Otto von Guericke, also found that a globe, made partly of sulphur, gave out light when rubbed, and that this light was best seen in a dark room.

Most of these experiments were made out of curiosity, and it was a very long time before any real use was made of electrical power. Some tests did not work as they were expected to do, and more than one man lost his life as a result of experimenting with electricity. The most useful things these early electricians learned were that the magic power could be stored in a glass jar, called a Leyden jar, and that it could be passed along wires.

(*b*) Carrying Electricity across the Thames.

In 1747, a great discovery was made. It was found that electricity would pass through water without a wire. The test was made in this way. Three men went to the River Thames, near London Bridge. One set to work to make electricity by turning a glass wheel. The electricity or current, as we call it, passed into a glass jar. A chain was fastened to the jar. The other end of the chain was held in the right hand of a man who, with his left hand, held an iron rod in the water.

On the opposite bank a third man held a rod in one

hand, and in the other the end of a wire. The wire passed over the water, being held up by men in boats, and entered the jar.

A wonderful thing happened. The electric current passed from the jar, along the chain, through the body of the man holding it, and down the rod into the water. Then it passed through the water without a wire, and was caught by the rod of the man on the opposite bank. It then passed through that man's body, along the wire back to the jar.

In another test an electric current passed through the water of a river, and set fire to some brandy in a cup on the opposite bank. The men wanted to see how long it would take for the flame to be started, but it happened so quickly that it seemed no time at all.

(*c*) Electricity in the Clouds—Drawing down Lightning.

BENJAMIN FRANKLIN (1706–1790).

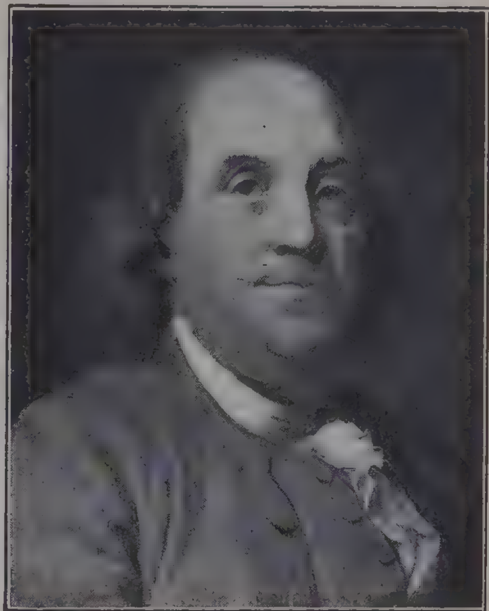
When men began to play with electrical sparks two hundred years ago, some of them noticed that the sparks were very much like lightning. They began to wonder whether lightning was just a big electric spark.

The first man to make a note of this was a very celebrated American, Benjamin Franklin. In his notebook he wrote: "Lightning is like an electric spark. It has the same smell of sulphur. It goes crookedly like a spark. It will go through rain as electricity goes through water. Someone ought to find out for certain whether lightning is electricity."

Franklin wrote to a friend in England, telling him of his idea, and the friend passed it on to men of science in France; but it was some years before anything was done to prove it. Then Franklin and a Frenchman,

named Dalibard, happened to make tests almost at the same time.

Dalibard built a little wooden shed in his garden, and fixed an iron rod through the roof, its point about forty feet from the ground. On a stormy night in May, 1752, he went into the shed. The lightning flashed and the thunder roared, but Dalibard stood patiently holding a piece of iron near the lower end of the rod. At last the lightning struck the top of the rod, and a spark leaped from the other end. Then it was certain that lightning was a form of electricity.



Benjamin Franklin.
National Portrait Gallery.

A few weeks later Franklin made his test. He used a kite made of silk, with a very sharp pointed wire fixed to the upright stick of the cross so as to rise a foot or more above the wood. A silk ribbon was tied to the string of the kite next to the hand, and a key hung at the junction of silk and string.

During a thunderstorm, Franklin and his son went out and raised their kite. Time after time they sent it up into the air, but the lightning did not reach it. Franklin was beginning to think that they had taken a lot of trouble for nothing, when a flash struck the kite. The loose ends of the string stood out every way, and the key gave out sparks.

Franklin held the wire point of an electric jar near the key, and found that he could collect electricity which acted in the same way as that made by an electrical machine. It is a wonder that Franklin did not lose his life in this experiment. A Russian, who tried to repeat it for himself, was killed.

(*d*) How Franklin used his Knowledge.

Having succeeded in drawing electricity from the clouds, Franklin wanted to make some use of this discovery that lightning was a big electric spark.

It often happened that, in great storms, church towers and other high buildings were struck by lightning and badly damaged, sometimes even set on fire and destroyed. Franklin got the idea that an iron rod fixed to the top of a building might attract the lightning, and it could be carried to the ground safely by means of a wire.

It was some years before he worked out the idea properly. In 1760, he set up a long rod above the shop of a merchant in Philadelphia, and waited patiently for a thunderstorm. When the storm came, the lightning struck the rod, and passed to the ground without injuring the building.

Soon other buildings were fitted with "Franklin rods," or "lightning conductors." It is said that in Paris, during storms, people might have been seen wearing bands of metal round their hats, with long wires from the metal trailing behind them to the ground.

The lightning conductor was the first really useful result of "playing with amber and the magic spark," but the experiments made added something to the little store of knowledge about electricity.

(*e*) What the Frogs' Legs taught the Electricians.

GALVANI (1737–1798).
VOLTA (1745–1827).

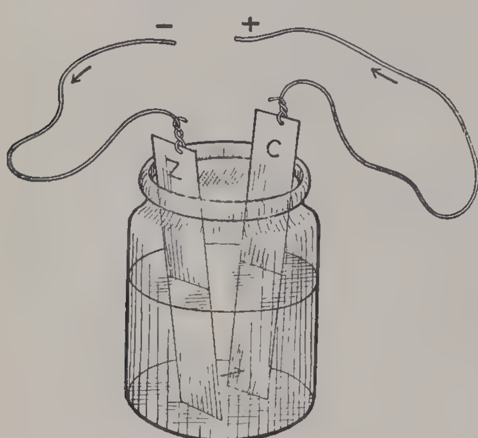
So far men had learned how to make an electrical current by means of an electrical machine, that is, by rubbing or friction, but this current was neither powerful enough nor steady enough to be of much use. Then, in a rather roundabout way, another great discovery was made that resulted in the electric battery.

In 1790, Galvani, an Italian scientist, was making some tests with frogs' legs in order to find out whether there was any electricity in animals. Some dead frogs lay on a table near the electric machine in his work-room. One of the assistants happened to touch the legs of one of the frogs with a knife, and he noticed to his surprise that the legs jerked. Another assistant thought this only took place when a spark was coming from the machine.

Galvani was told of this, and he made further tests. He found that whenever the frogs' legs were touched by two different metals, they gave a jerk. He tried the effects of different pairs of metals, iron with brass, lead with silver, and so on, and decided that silver was the best conductor of that "animal electricity" which he believed he had proved to exist.

Another Italian, named Volta, who had already made a clever little machine for producing electricity, did not, however, believe that Galvani's theory was correct. He did not think there was electricity in the legs, so he set to work to find out in what other way the jerks could be caused. His long series of careful experiments not only proved that his idea was right, but led on to most valuable discoveries—the electric pile and the electric battery.

Volta was helped by a very curious experiment. He had two plates of metal, one of lead, the other of silver. He put one on the top of his tongue, and the other under his tongue. As soon as he brought the edges of the plates together, he noticed a peculiar taste. There was no such taste when the plates did not touch, and two different tastes could be got by putting one or the other on the top of the tongue. No effect was obtained when the two plates were of the same metal.



A simple Electric Cell.

These tests led Volta to decide that the jerks noticed by Galvani were really due, not to animal electricity, but to the contact between two pieces of different metals. The frogs' legs in Galvani's experiments, or the tongue in his own experiments, simply acted as a conductor for the electricity produced as soon as the two metals touched each other.

Volta showed that conductors of electricity were of two classes, solid, such as metals, and liquid, such as water and solutions of various kinds. He also proved that better results were obtained by the use of the two kinds of conductors in combination.

In 1799, he made an apparatus still known as the voltaic pile. He fixed four glass rods in an upright position, and cut a large number of round plates of zinc, copper, and cardboard. The cardboard he soaked in salt water. He laid a plate of copper at the bottom between the four glass rods. On this he placed a plate

of zinc, then a plate of cardboard; next, a plate of copper, then a plate of zinc, then another piece of cardboard; and so on, until he had made a big pile.

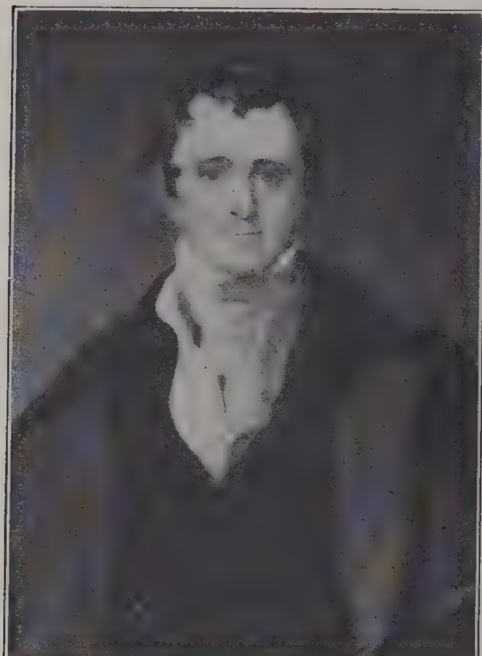
Volta found that such a pile gave a little spark on attaching a wire to the top of it, and bringing the other end of the wire in contact with the bottom of the pile. The pile, however, ceased to work when the cardboard dried; while if it was too wet, the water ran down the sides and interfered with the proper contact of the metals.

Volta's next plan was to use salt water in a number of cups or cells to conduct the electricity from one pair of metals to the next. The metals for this experiment were in the shape of flat bands, soldered together in pairs, a copper band and a zinc band. The cups were arranged in the form of a crown.

At first neither the spark obtained from the pile, nor that from the "crown of cups," was strong enough to prove that the electricity produced in this way was the same as that produced by an electrical machine. Then, quite by chance, the proof came. It was already known that charges of electricity from a Leyden jar, passed through water several times, had the power of breaking up the water into two gases, hydrogen and oxygen. One day, at the end of the eighteenth century, a very noted man of science, named William Nicholson, was using a voltaic pile, when he put a drop of water on the plate, just where the wire touched it, thinking to improve the contact. At once he saw tiny bubbles appear in the drop of water. He tried the experiment on a larger scale, and proved that the action of the electric pile was equal to that of the machine.

One of the first uses to which the electric pile was put was that of breaking up chemical solutions. This was very helpful to students of chemistry. Then, in

1808, Sir Humphry Davy had a great pile or battery set up at the Royal Institution, in London; it consisted of 2,000 pairs of plates. The first experiment performed with it was the production of electric light. When Sir Humphry joined the ends of the two wires, and separated the wires again, a dazzling light played between the two ends. The light was too bright for common use, and the heat was so great that the wires rapidly melted. Many years passed before electric light could be used for ordinary lighting, but of that we shall read later.



Sir Humphry Davy
National Portrait Gallery.

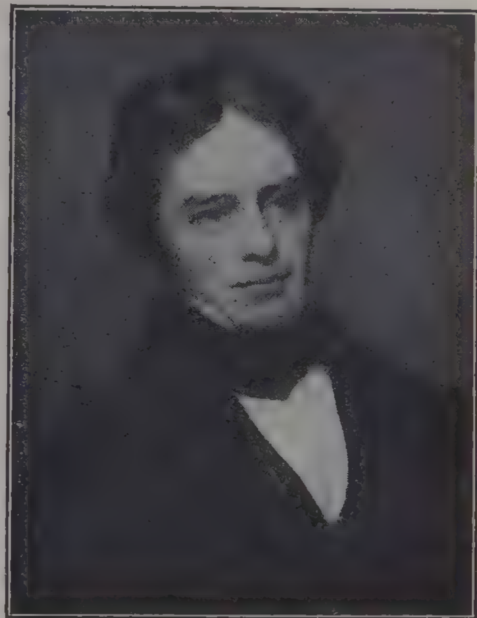
The First Dynamo.

MICHAEL FARADAY (1791–1867).

In the early days of the nineteenth century, a boy, who was to become one of the greatest of electricians, was running errands in the streets of London. This was Michael Faraday, a blacksmith's son. After a year as an errand boy, he was apprenticed to the trade of a bookbinder. He did not like the work, and all the time he could spare from it he spent in making chemical and electrical experiments. When he could get the money to pay for admission, he attended lectures on these subjects.

The lad's interest in science attracted the attention of a certain Mr. Dance, one of his master's customers, and, in 1813, he took Michael to hear four lectures by

Sir Humphry Davy. Michael made careful notes of the lectures, and when the course was over, he copied out the notes very neatly, and sent them to Sir Humphry, with a note saying how much he would like to follow in his footsteps. Sir Humphry replied at once, in a kindly manner, promising to find some scientific work for his young admirer. He kept his word, and, a year later, invited Faraday to become his assistant at the Royal Institution.



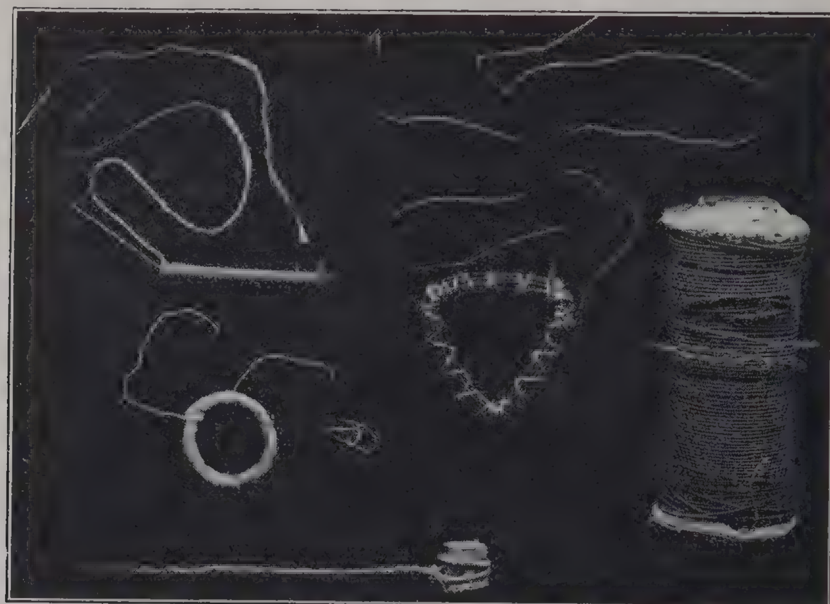
Michael Faraday.
National Portrait Gallery.

Before he had attended the lectures, Michael had made his first voltaic pile, using seven halfpence, seven discs of zinc, and six pieces of paper moistened with salt water. Although other important things had to be done at the Institution, Faraday turned eagerly to electrical experiments whenever possible, and his greatest work was in connection with electricity.

In 1831, he proved that an electric current could be produced by means of a magnet, without any electric battery. He continued his experiments, and discovered the currents produced by "induction coils." These coils consist of a cylinder of iron surrounded by a coil of copper wire, with yet another coil of very fine wire round that. An electric current is started and stopped in rapid succession in the first coil, and each starting and

stopping produces or "induces" a momentary current in the outer coil.

After this discovery Faraday was able to make a model of a machine called, for shortness, a dynamo (in



Some of the original coils used by Michael Faraday.
About two-fifths actual size.
Courtesy of Science Museum.

full, dynamo-electric machine). His little machine, when turned by hand, caused the power of the man to re-appear as an electric current. Ever since that time, inventors have been working to develop and improve the dynamo, until we have now great machines of 5,000 horse-power, worked by steam- or gas-engines, which serve to provide cities with electricity; while other dynamos of varying power are used in countless ways.

A dynamo consists of two things. One of them is a great magnet that produces a powerful magnetic field. The other is a set of coils of wire, which, driven by the engine, moves through the magnetic field, and, as it

moves in and out, becomes the bearer of a momentary induction current. So fully did Faraday work out his idea that, with all the developments, the theory of dynamo action which he laid down remains almost unchanged.

We shall return to the subject of electricity later on.

QUESTIONS.

1. Summarize in order the discoveries made with regard to electrical power.

2. What great advance in electrical knowledge did Franklin make? Describe his famous experiment. What use was made of his discovery?

3. Explain what a voltaic pile is, and what is its use. What previous discoveries led to Volta's? How did Sir Humphry Davy improve on the idea?

4. Explain Michael Faraday's discovery. In what way is it the basis of present-day electrical engineering?

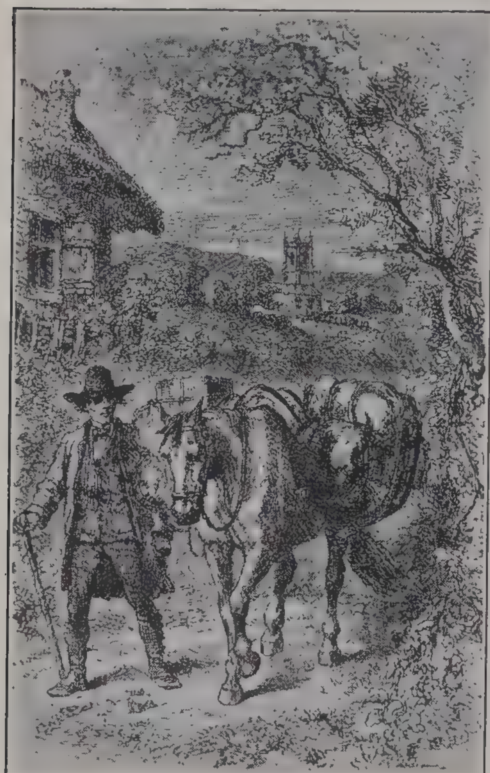
5. GREAT ENGINEERS—CANALS AND ROADS.

(*a*) The Roads of Old England.

Up to the eighteenth century the roads of England were very bad. For nearly fourteen hundred years, since the time of the Roman occupation, little had been done in that direction. The old Roman roads had been neglected, though they still formed the great highways of the country. In most cases the main road of a parish was a mere horse track across a miry common, or a watery lane twisting between high banks and overhanging hedges. These lanes were so deep and narrow, a writer tells us, that during a cross-country hunt the stag, hounds, and huntsmen have been known to leap over a loaded wagon in a hollow way without touching it.

The state of the roads made the use of pack-horses, instead of carts, frequently necessary. Coal needed by

country smiths in the Midlands was brought slung over the backs of horses, because the roads were too bad for carts; and, for the same reason, horses and donkeys in the Potteries carried packs and panniers filled with crates of pottery and bolls of clay. Until the road was made down the Taff Valley, in 1767, coal was carried from the Merthyr and Dowlais districts on the backs of ponies and donkeys over mountain paths into Herefordshire, and down to Cardiff.



A Pack-horse. Heavy goods, such as coal or clay, were carried in huge baskets or panniers.
Rischgitz.

There were very few bridges, and in many places, where the river was too deep to drive through, coaches and wagons were taken across on a large flat-bottomed barge kept for the purpose. To get a coach and six horses on to one of these ferry-boats, and then punt it across, took up a good deal of time.

Stage coaches ran between London and some of the large towns, but they were very slow, travelling at the most five miles an hour. In 1700, it took a week to get from London to York; and a Yorkshireman, who had to take such a terrible journey, made his will before starting, and bade a solemn farewell to all his friends. In 1713, there were so-called "flying coaches," drawn by

six horses, and travelling at the rate of eight miles an hour, but they were expensive, and the speed was thought dangerous.

Even a short journey was uncertain and difficult. In 1727, the king, George II, and his wife, trying to reach Kew from St. James's Palace, passed a whole night on the road; and once, between Hammersmith and Fulham, the coach upset altogether, and they were thrown into the ditch.

Daniel Defoe tells of a Sussex lady whose coach had to be dragged to church by six oxen, the road being too bad for horses.

The reason for this state of affairs was that there were no properly paid persons appointed specially to look after the roads. The work was left to the overseers of each parish, whose duties were mainly connected with relief of the poor. Each parish was supposed to send men to work for six days in the year on the roads; but the road-menders made a sort of picnic of the occasion, and the roads got worse and worse, as traffic increased with the growth of manufactures.

(*b*) The Turnpikes.

Towards the end of the seventeenth century an effort was made to improve the roads by setting up Turnpike Trusts. Each of these committees or boards was charged with the duty of making and repairing a certain piece of road. To pay the expenses of this work, they were authorized by Act of Parliament to collect a toll or payment from persons driving coaches or wagons over the road. Gates were set up across these roads, and placed in charge of a toll collector, who lived in a little cottage by the gate. On payment of the toll, the gate was opened, and the coach or wagon was allowed to drive through.

During the Rebellion of 1745, when the Young Pretender marched from Scotland into England, and troops had to be hurried to the north, the Government saw what a danger bad roads might be to the safety of the kingdom.

Toll-house and Toll-gate on a Turnpike Road. From the picture by Theo. J. Gracey in the Belfast Museum. *Rischgitz.*

The consequence was that, within the next few years, four hundred Acts of Parliament were passed, for repairing the roads in different parts of England.

At first the new turnpikes were very unpopular. In many parts of England there were riots, and the toll bars were burned or wrecked. Even as late as 1843 riots took place in Wales on account of the heavy charges at the toll gates. Turnpikes may not have provided the best means of maintaining the highways in repair, but the Trusts did useful work.

(*c*) Three Great Road-Makers.

John Metcalfe (1717–1810).
Thomas Telford (1757–1834).
John McAdam (1756–1836).

John Metcalfe, known as "Blind Jack of Knaresborough," was a very remarkable man. He was the son of poor parents, and lost his sight when he was six years old after an attack of smallpox. Although he was blind, Metcalfe became a clever horseman and a daring tree-climber. He could guide a traveller across the wildest moors round York and Knaresborough, and was a successful tradesman and carrier.

In 1765, he began the work of repairing a Yorkshire road. He used to walk about with a stick, feeling the surface of the road; then he could tell his workmen how to do the work. Blind though he was, he had no difficulty in planning culverts, bridges, and embankments on the worst surface.

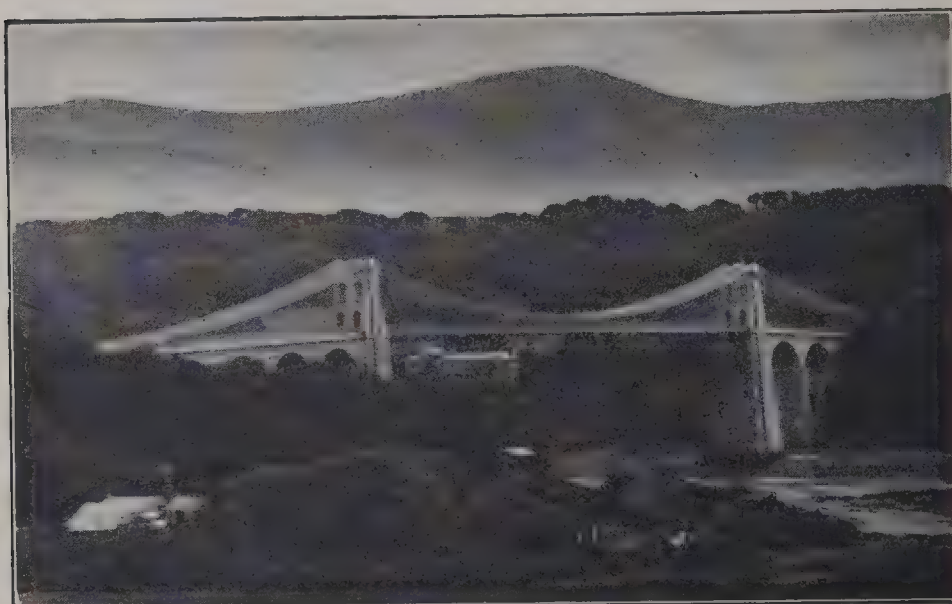
Between 1765 and 1790, Metcalfe had charge of road-making in Yorkshire, Lancashire, and Cheshire, and several of the principal roads in those counties are his work.

Thomas Telford, like Metcalfe, was a self-made man. He was the son of a Scottish shepherd, and from early childhood worked as a herdboy. He had very little chance of going to school; but when he was able to go, he was so quick-witted and eager to learn that he made the most of his time.

At the age of fifteen, Telford was apprenticed to a stonemason. In his spare time he learned Latin, French, and German. After working in Edinburgh and London, he was employed by the county of Shropshire as Surveyor of Public Works, with charge of the construction of roads and bridges. He built no fewer than forty-two

new bridges, besides repairing roads and making a canal.

In 1804, he was busy making roads through 920 miles of the most difficult country in Scotland. Ten years later he was doing similar work in Wales. This work



The Menai Suspension Bridge. *E.N.A.*

included the famous suspension bridge across the Menai Strait; it was designed by Telford in 1819, and the first chain carried across in 1825. The total cost was £120,000.

Another famous road-maker was John Loudon McAdam. He, too, was a Scotsman, a descendant of the famous McGregor clan. While still at school, he was interested in road-making, and made a little model of a road section. When he was fifteen, he was sent to New York, to work in the office of a merchant uncle. He returned to Scotland in 1783 with a fortune, and bought an estate. He soon took up his old hobby, road-making,

but the people in his neighbourhood were not interested in his experiments.

Later on, when he moved to England, and settled near Bristol, he became a member of the Turnpike Trust, and this gave him a chance of putting his ideas of road-making into practice.

His plan was to use big stones for a foundation, and to drain off the water; then to utilize broken stones, not larger than would go into a man's mouth. These small stones, when rolled down, bind together into a smooth surface, which must have a slight curve on it to drain the water away. Although many and great improvements in road construction have been made since McAdam's time, his method is still the basis of present-day road-making.

The Government were at this time making inquiries about road-making. They found that McAdam's plan was the best, so they made him General Surveyor of Roads. In sixteen years he travelled on 30,000 miles of road. When he went to Scotland, he used to travel in a closed carriage drawn by two horses, followed by a Newfoundland dog and a pony. He used the pony to carry him to any spot off the main road that he wanted to visit.

The result of better roads was, of course, quicker travelling. Oxford could be reached from London in six hours instead of two days, and even the journey from London to Manchester was done in twenty-four hours. More coaches ran, and it became the custom to send letters by these, instead of by postboys. Merchants, too, carried their goods more easily. Covered wagons could be used instead of strings of pack-horses. Farmers were able to drive their cattle and carry their corn, butter, and cheese to more distant towns, where they got better prices, and they were glad to try the new ways of farming so that they might have more to sell.

(*d*) Two Great Canal-Makers.

James Brindley (1716–1772).
John Smeaton (1724–1792).

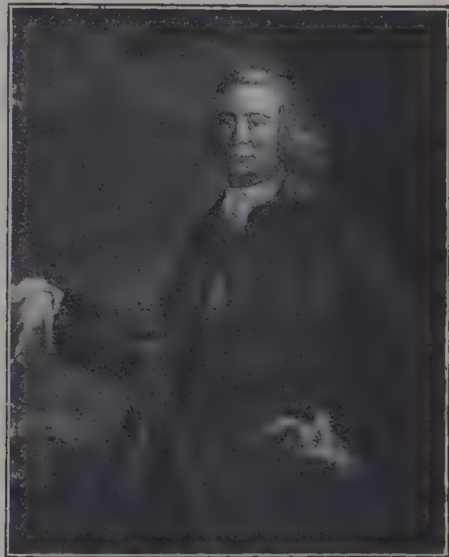
The new roads, however, did not suffice for moving the quantity of heavy goods that all the new markets were demanding. A method was sought that would enable the more heavy material to be moved, and to be moved quickly. Barges could carry goods more cheaply on *canals*, and could carry greater quantities than carts or pack-horses could carry on tracks or roads.

France had already found out the great advantage of canals, three having been made in that country during the seventeenth century. When the Romans were in Britain, they made two canals, the Foss Dyke and the Caer Dyke, the former of which is still navigable, and extends from the River Trent at Torksey to Lincoln. But in the centuries since the Roman occupation not a single canal had been made. There were many rivers, indeed, but they were of little use, for the channels were choked with mud, sand, and weed.

One of the largest coal owners of the eighteenth century was the Duke of Bridgewater. He had coal mines at Worsley, in the south of Lancashire. The busy little town of Manchester (as it was at that period) was seven miles away, and the people there needed coal. But the cost of taking coal from Worsley to Manchester on pack-horses was nine or ten shillings a ton, and this made the coal very dear.

The Duke thought he would have a canal cut, but his friends laughed at his idea. However, he determined to try it. At last he found an ingenious mechanic and engineer, named James Brindley, who said he could plan a canal, and superintend its construction.

James Brindley was a native of Derbyshire. His parents were too poor to give him any but the scantiest schooling, so James could hardly write his own name. When he was seventeen, he was apprenticed to a wheelwright, and, by and by, set up in business for himself at Leek; he was soon known for his skill in repairing machinery. In 1752 he set up an engine for draining water from some coal-pits at Clifton, in Lancashire. Three years later he completed some machinery for a silk mill at Congleton.



James Brindley.
Photo.: W. F. Mansell.

The Duke of Bridgewater heard of his skill and ingenuity, and in 1759 he asked him what he thought of his idea of having a canal made. Brindley was quite ready to undertake the work.

It was a very difficult task, for the water had to be carried on a bridge or aqueduct, across the River Irwell. Brindley took two years to make this canal, which was finished in 1761.

The Duke's idea proved to be a great success. The barges could carry coal along the canal at exactly half the cost of carrying it on horseback; and so the people of Manchester got their coal much cheaper. The Duke was so pleased that he decided to risk the cost of a canal between Manchester and Runcorn on the Mersey. He had the greatest difficulty in raising the money for the canals, but he was soon repaid when they were opened.

Brindley then planned the Grand Trunk Canal, connecting the Trent and Humber with the Mersey, and extending, with all its branches, to a length of 139 miles. In this canal the water had to be taken through a tunnel, instead of over a bridge. This tunnel, at Harecastle, in

Barton Road Aqueduct over the Manchester Ship Canal, showing the swing bridge and the water within, and the closed end of the canal. This aqueduct was originally over the River Irwell, which now forms part of the Ship Canal. *E.N.A.*

Staffordshire, is 2,880 yards long, 12 feet high, and 9 feet wide. It has no towpath, and the boats are moved along by men lying on their backs and pushing their feet against the tunnel wall. The men who do this hard work, are called "leggers."

It was Josiah Wedgwood, the famous potter, to whom the idea of this canal was due, and he cut the first sod in 1766. No part of England benefited more by canals than the Potteries. "China" clay, lime, and coal had all to come from a distance; and the goods, when made, were difficult to carry by road, being both bulky and brittle. The cost of water-transport, too, was only

one-fourth of the rate by road. Corn also was carried at less cost by canal, and so bread became cheaper.

Altogether Brindley planned three hundred and sixty miles of canals.

He was never an educated man, but he was an engineering genius, and was gifted with remarkable powers of mind. When he had a difficulty to overcome in his work, he would not solve the problem on paper, but simply go to bed and stay there in deep reflection, until he had thought the matter out and knew what to do.

John Smeaton was the son of a lawyer of Austhorp, near Leeds, but he was of Scottish descent. As a boy, he was very fond of making model engines. He had a small lathe, and many other tools, which he made for himself, doing his own casting and forging.

On one occasion he made a pump, and it worked so well that he pumped dry a small fishpond in his father's garden at Austhorp Lodge.

When he was sixteen, he left school and went into his father's office. Two years later he was sent to London to study law. His father had a good business, and hoped his son would carry it on, but John hated the law, and no promises of future prosperity would tempt him to go on with his legal studies. He wanted to make things. At last, his father allowed him to go to a scientific instrument maker to learn the trade. Some years later he set up in business for himself.

In his business Smeaton met many gifted men of science. He was interested in the scientific experiments and inquiries of the day, and became a Fellow of the Royal Society, the leading scientific society in England. He attended the Royal Society's meetings, and read papers, for one of which he received the Society's medal. He made a tour of the Netherlands in 1754, and studied

the great canal works of foreign engineers. In 1756, he was asked to superintend the building of a lighthouse on the Eddystone Rock, fourteen miles south-west of Plymouth; but the history of that engineering feat belongs to another chapter.

After the lighthouse was finished, in 1759, Smeaton was engaged in planning roads, bridges, and canals; but, owing to lack of public funds, many of his schemes were not carried out. In bridge-making and canal-making his chief work lay in Scotland. There he planned three handsome bridges still standing, at Perth, Banff, and Coldstream respectively. His only bridge in England, over the Tyne at Hexham, was finished in 1777; but, owing to weak foundations of the piers, it was swept away in a severe flood five years later.

John Smeaton.
National Portrait Gallery.

Smeaton's great work as a canal-maker was the Forth and Clyde Canal. This was the most important work of its kind which had been carried out in Britain up to that time. It was begun in 1768.

Smeaton's canal followed very closely the line of an old Roman wall. It was thirty-eight miles long, and had thirty-nine locks. Owing to the difficulty of obtaining money, however, the canal was not finished until 1790.

During his frequent visits to London from his

Yorkshire home, Smeaton gathered together a few friends, who, like himself, were interested in engineering work, and so formed a club, "The Smeatonians," which met on Friday nights. From this club sprang the now important society known as the Institution of Civil Engineers.

Smeaton was a man of simple tastes and few wants. He might have made a huge fortune by accepting invitations to Russia, where much engineering work was in progress; but no reward, however great, would tempt him to leave his native land. He died at Austhorp in 1782.

Thomas Telford, who attained great eminence in the construction of roads and bridges, also took his share in canal-making, his great work being the Caledonian Canal in Scotland. James Watt, when he was engaged in land surveying in 1773, showed that such a canal would be possible, but the work was not begun until 1803.

Questions.

1. Summarize what you have learnt of the work of the great road- and canal-makers.

2 Explain the references in these lines from *John Gilpin* :—

"And now the *turnpike gates* again
Flew open in short space,
The *toll-men* thinking, as before,
That Gilpin rode a race."

3. Write about the roads of your own district, their surface and upkeep. Find out what authorities are responsible for their repair. Illustrate with a map, showing the main roads, and stating where they lead to.

4. Are there any canals in your district? If so, say where they lead to, and for what purposes they are used. Are they still useful, or has their use been discontinued? Find out to whom they belong.

5. Say what you know about Roman roads in this country. Are there any in or near your own district?

6. What is an aqueduct? Give some account of the one mentioned in the foregoing chapter.

6. GREAT ENGINEERS—Lighthouse Builders.

(*a*) Lighthouses of Olden Days.

The earliest known lighthouses were those on the coast of Lower Egypt, tall towers on which beacon fires were kept alight. The work of watching and tending these fires was entrusted to the priests. The Pharos, a lighthouse at the entrance to Alexandria Harbour, was one of the wonders of the ancient world. It was built during the third century B.C., and was destroyed by an earthquake fifteen hundred years later. It took its name from the rocky island on which it was built, but it was so famous that the name *pharos* was afterwards given to other lighthouses built by the Romans.

Probably the oldest lighthouses in Western Europe were the Pharos at Boulogne and the Pharos at Dover, one on either side of the Channel. Both have now disappeared. The oldest lighthouse still in use is the light of Cordouan, at the mouth of the Gironde, in France. It was built in the fifteenth century on the site of an older tower.

In the seventeenth and eighteenth centuries many towers were built, on the top of which were placed braziers or grates containing coal or wood fires. Lighthouses of this kind were set up at Tynemouth (about 1608), the Isle of May (1636), St. Agnes (1680), St. Bees (1718), and the Lizard (1751).

In this chapter you will read about the engineers who built the famous lighthouses on the Eddystone Rocks, in the English Channel.

(*b*) Henry Winstanley (1644–1703).

Henry Winstanley was probably a native of Saffron Walden. He was employed by the Earl of Suffolk to

superintend some building at Audley End; later, he entered the service of Charles II, and had charge of the workmen employed on a royal palace at Newmarket.

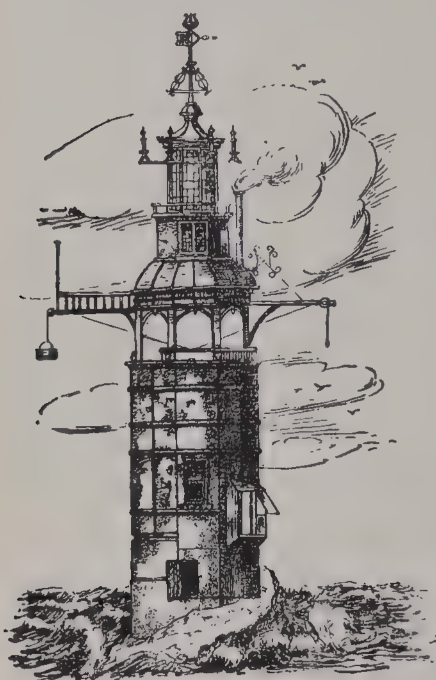
Winstanley was a man of very varied interests and abilities. He published sets of beautifully engraved pictures, and was interested in all the new ideas of his time. He invented many curious mechanical devices, with which he amused the visitors to his house at Littlebury in Essex. He also set up a place of amusement, called the Water Theatre, in Piccadilly.

At this time, the number of ships crossing the ocean was increasing. British colonists had settled on the shores of the New World. British merchants were trading with India and the East. Many of these ships sailed along the English Channel, and had to pass a dangerous reef of rocks, the Eddystone. These rocks were covered with water at high tide, and many a gallant ship struck the hidden reef and was lost.

Towards the end of the seventeenth century, men began to ask whether a lighthouse might not be built on the reef, but when they tried to do this, the difficulties were too great. The rocks were exposed to wind and tide; they were difficult to reach, being fourteen miles from the shore; and they were, as already said, covered by the sea at high tide. Builders shook their heads, and said, "It is impossible." But, in 1695, Henry Winstanley offered to build a lighthouse on the Eddystone. There is a story that he was staying in Plymouth, when a vessel was wrecked on the fatal reef, and he was so grieved at the loss of life so near home that he was moved to undertake this great task of engineering.

His offer was accepted, and, in 1696, he set to work. The first summer was spent in making twelve holes in the rock, and fastening twelve great iron rods to hold

the work. The task was very difficult ; for the rock was so hard, and the time that it was above water was so short, that very little could be done at one visit. Sometimes the sea was too rough for the workmen to land at all, and more than once, the boat, on its return to land, was driven ashore some distance from Plymouth, and the whole of the next day was taken up in getting back to the town.


Winstanley's Eddystone Lighthouse.

The second summer was occupied in building a solid pillar, twelve feet high, and fourteen feet in diameter. That season the men had more time to work at the rock, and managed a small amount of shelter, but their great trouble was in getting the materials to the reef, and making them secure at night.

The third year saw the completion of the work under great difficulties. First the pillar had to be strengthened, and increased to sixteen feet in diameter. Then the upper stories were built of wood. In order to save time, Winstanley decided to lodge with his men on the rock. The very first night, bad weather set in, and the boats from the shore were unable to reach the builders for eleven days. During that storm, the water was washing over the rock nearly all the time ; and although they did their best to rig up shelters, the men and their stock of provisions were soaked through and through.

On November 14th, 1698, the first light shone from the Eddystone. But again bad weather set in, and it was not until three days before Christmas that a relief boat could come from the shore. By that time the lighthouse keepers had come to the end of their provisions, and were enduring great hardship.

Winstanley's tower stood eighty feet high. It was of a curious shape, many-sided, with galleries and projecting corners; yet, though so oddly constructed, for five years it sent its warning light across the waves. In 1699, having been badly damaged by storms, the tower was made solid to a height of twenty feet, and strengthened by an outer ring of strong masonry.

Winstanley was told by his friends that the many galleries and projections he had given to his tower would not stand heavy seas and high winds, but he replied that he was quite certain the tower was safe. He added that he only wished he might be in it during the greatest storm that ever blew, so that he might see for himself what effect it would have on the building.

His wish was granted, but he did not live to tell the tale. In November, 1703, he visited the lighthouse with some workmen to see about repairs. A fearful storm arose, and during the night the light on the Eddystone suddenly went out. The next morning, it was seen that the tower had been swept away. Mr. Winstanley, the workmen, and the lighthouse keepers were all drowned. A few of the great irons were all that remained on the rock; of the rest of the tower, nothing was ever found, except a piece of chain that had become wedged into a rock-cleft, and was cut out fifty years later.

(*c*) The Second Eddystone Lighthouse.

John Rudyerd's Tower.

Soon after the destruction of the first Eddystone Lighthouse, a Virginian man-of-war was wrecked upon the rock where the tower had stood. The loss of this vessel, the *Winchelsea*, with the greater part of her crew, hurried on the building of a second lighthouse.

The builder was a certain Mr. John Rudyerd, who was neither an architect nor an engineer, but a silk merchant of Ludgate Hill, London. He was, however, supposed to possess a genius for mechanics, as well as being a shrewd business man. His lighthouse was begun in 1706, and finished in 1709.

At this time, England was at war with France, and one day, while Rudyerd and his men were at work on the reef, a French privateer swooped down on them, carried them off to France, and cast them into prison. The captain of the French vessel expected a reward for his smartness, but when the French king, Louis XIV, heard of it, he was angry. He said that though he was at war with England, he was not at war with mankind; and he declared that a light on the Eddystone Rocks was of as much service to the French sailors as to the English. He ordered Rudyerd and his men to be given presents and sent back to their work, and the interfering captain to be imprisoned in their place.

Rudyerd's tower was built of oak, but was of very simple design, without the galleries and projections that Winstanley had planned. It stood the strain of wind and wave for forty-six years, and then it was destroyed by fire.

On December 2nd, 1755, at two o'clock in the morning, Henry Hall, one of the three men in charge, went into the lantern chamber to snuff the candles. He found the

place full of smoke, and as he opened the door a flame burst out. A spark from one of the twenty-four candles must have caught the woodwork, or the flakes of soot hanging from the roof. Hall shouted to his companions, but had some difficulty in arousing them, for they were fast asleep. Meanwhile, he tried to put out the flames by heaving water from a tub that was kept ready, but the fire was burning twelve feet above his head. The other men came to his help, and went for more water.

They had to go down and return a distance of seventy feet, and, as the fire increased, the men were driven from room to room, until at last they took refuge in a hole or cave in the rock, it being low tide. At ten o'clock help came from the shore, and the men were dragged almost unconscious through the water to the boats.

Hall was an old man of ninety-four, but strong and active. He was placed under a doctor's care, but he died some days later.

(*d*) Smeaton builds the Third Lighthouse.

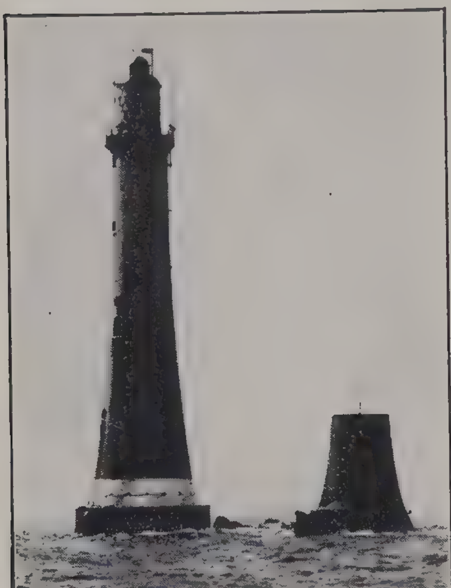
After the loss of the second lighthouse, the President of the Royal Society was asked to recommend an engineer to build a third tower. He suggested John Smeaton, of whose work as a canal-maker you read in an earlier chapter.

Smeaton at once set to work on a model lighthouse. He designed it after the form of the trunk of an oak tree, gradually decreasing in size from the base to a certain height. He thought stone would be the best material to use. Other people told him that a stone tower could not possibly stand on the Eddystone; it would overturn. But he had his way, and proved that he was right.

Smeaton was the first lighthouse builder to use dove-tailed joints for the stones. By dovetailing is meant

that a piece, cut in the form of a dove's outspread tail, projects from one stone, and fits into a space of the same shape in the next stone.

In August, 1756, the work was begun by Smeaton marking the centre of the base. The rest of the season was spent in cutting out dovetails in the rock, ready for the stones to be fitted in. The winter was spent in preparing the stones in the yard in Plymouth. They averaged a ton in weight. Each one was carefully set out on a large floor, and then cut and trimmed to the true shape.



The present Eddystone Lighthouse, built by Sir James Douglas, and the remains of Smeaton's Lighthouse.
E.N.A.

Just before Midsummer the following year the first stone was fixed in its place. The work went on slowly; bad weather, high tides, and other difficulties hindered the builders. England was again at war with France; and, on one occasion at least, the crew of the ship bringing stone to the lighthouse was carried off by a press-gang to serve in the Navy. But by August, 1759, the lantern was built, and in October of the same year the light shone once more on the Eddystone. On the granite round the top of the store-room Smeaton ordered this text to be carved, "Except the Lord build the house, their labour is but vain that build it." On the east side of the lantern were carved the words, "Laus Deo" ("Praise be to God"), and the date, August, 1759—the year of Wolfe's victory at Quebec.

The light was supplied by twenty-four candles, carried in a chandelier. Oil was not used, because lamps were apt to smoke and form a film on the glass, thus dimming the light. On a clear night the light was plainly visible from Plymouth Hoe.

For more than a century, Smeaton's tower stood firm, braving storm, wind, and tide. But, in 1877, it was found that the rock on which it stood was being worn away by the waves. Then a new lighthouse was built on another part of the reef by Sir James Douglas, who copied Smeaton's plan of dovetailing the stone.

When the new lighthouse was finished, in 1882, Smeaton's tower was taken down to the level of the first room, and re-erected on Plymouth Hoe upon a base copied from the one on the rock. So there are two monuments to that great engineer, the base of his tower on the rock, close to the new lighthouse, and his lighthouse on the Hoe.

The weight of stone in the present Eddystone Lighthouse is about 4,668 tons. The light was originally supplied by oil lamps ; but, in 1904, incandescent oil vapour burners were put in, and these give as much light as 292,000 candles.

Questions.

1. What difficulties are there in making lighthouses ? How did the early builders meet these difficulties ? Find out how they are met to-day.

2. Who built the first three lighthouses on the Eddystone reef ? What differences were there in material, shape, and foundation ? What happened to the first two, and how long did the third one last ?

3. If you have visited a lighthouse, describe your visit. If not, find an illustrated account of one, and write a description.

7. A GREAT ENGLISH POTTER.

Josiah Wedgwood (1730–1795).

(*a*) A Potters' Village in the early Eighteenth Century.

It has been said that nine-tenths of the cotton spun in England is spun within eleven miles of Manchester. It may be as truly stated that most of the earthenware made in England is the output of the "Five Towns," or rather of six—Fenton, Burslem, Tunstall, Hanley, Stoke, and Longton. These constitute the Potteries district in North Staffordshire.

From the beginning of the eighteenth century, this part of Staffordshire, extending nine miles from south-east to north-west, and about three miles from north-east to south-west, has had special advantages for this industry.

The fashion of tea-drinking which came into being at the end of the seventeenth century, and the increased number of coffee houses, caused a great demand for china and earthenware. Earthenware began to take the place of pewter, wood, and horn in household use. In 1688, a Dutchman, named Elers, taught English potters to make black and red ornamental teapots of Staffordshire clay, and from that time the north of Staffordshire became the centre of the potter's industry.

But the potters' villages of the early eighteenth century were small, separated from each other by strips of green moorland. Burslem, the largest of the villages, was known as the Butter Pottery, because of the large number of butter pots, coarse glazed jars about fourteen inches high, that were made there. The other earthenware was for the most part coarse and clumsy, and very easily broken.

There were fifty small master potters in Burslem.

Each had a single oven, and, as a rule, employed six men and four boys. After paying his assistants and drawing 6/- a week as his wages, the master made about 10/- a week profit. The ware was sold to travelling packmen who carried it about the country on horseback.

At the beginning of the eighteenth century there were seven small potters at Hanley (now a large town), but only one horse and one mule in the hamlet. There was no cart or wagon of any sort in Hanley. The coal used in the place was brought in baskets on men's or women's backs, the roads being almost too bad even for pack-horses. At Stoke there were only two cottages, and no pot works.

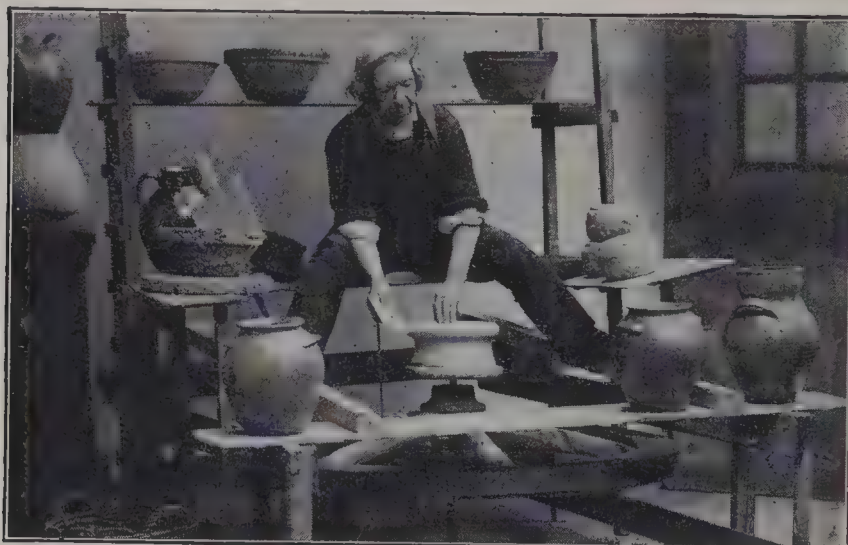
(*b*) The Young Potter.

Josiah Wedgwood, the man who became England's greatest potter, was born at Burslem, in 1730. He belonged to a family of potters; his father, several of his uncles, and many cousins were potters, as their fore-fathers had been for two centuries.

Josiah was the youngest of a family of thirteen children. His father owned a small pottery, the Churchyard Works. Of his childhood we know very little. He played on the waste ground near his father's works. He was very fond of horses, and often coaxed the packmen to give him a ride, while they were waiting for their loads. As soon as he could toddle, he was sent to a dame's school, the only school in Burslem, to learn his ABC.

When he was seven years old, he went with the other children to a school at Newcastle-under-Lyme, three and a half miles away, across the common. In his long walks to and from school, Josiah grew to love wild flowers, and this made him eager, in later years, to beautify his wares by painting them with pictures of flowers. But his school

days soon came to an end. When he was nine, and had just learned the beginnings of reading, writing, and arithmetic, his father died, and Josiah was taken from school to work in the pottery of which his brother Thomas was now master.



An old potter at his wheel. As the wheel turns round rapidly, the potter hollows out the soft clay with the fingers of his left hand, and shapes the vessel with his right, sometimes using a piece of wood or metal as a guide. *E.N.A.*

The boy was fond of making clay models, and was very clever at imitating any object in which he was interested. But the goods turned out at the Churchyard Works were not ornamental; butter pots, black and mottled ware, baking dishes, pitchers, milk pans, and porringers were the chief productions.

When Josiah was eleven years old, he was working as a "thrower." The thrower's work is to shape the moist clay on the wheel. A workman weighs a portion of clay, and hands it to the thrower who is seated at the wheel. The potter's wheel is a little round table, kept revolving

by a leather band. As the wheel turns round and round, the thrower shapes the ball of clay with his hands and fingers, copying a pattern he has before him.

Josiah was soon a clever thrower, but when he was eleven he fell ill with smallpox. All his family suffered, but none so badly as he did. The disease affected his right knee, and, even when he was well enough to leave his bed, he could walk only with crutches. As time went on the knee became less painful, but remained stiff. However, he went back to work, and was properly apprenticed at the age of fourteen.

After a time it was found that his stiff leg hindered his work as a thrower, and he became a moulder. One of his earliest efforts was an ornamental teapot, which is still preserved at Burslem, and is known as "Josiah Wedgwood's first teapot." He then tried mixing differently coloured clays in imitation of marble, tortoise-shell, and agate, and made pickle-leaves,* plates, knife-handles, and snuff-boxes. Although these found a ready sale, his brother Thomas had no sympathy with his "flights of fancy," and when his apprenticeship was over, refused to take him into partnership.

Josiah continued to work for his brother until he was twenty-one. Then he was paid £20 left him by his father, and removed from Burslem to Stoke. After a time he entered into partnership with a potter named Whieldon, and, among other improvements, produced a new green earthenware, very smooth and shiny like glass. Dessert dishes, formed like leaves, were made of this ware, and they sold well. But Wedgwood's knee was still troublesome, and he was often unable to go to the pottery. The work had to be done in his absence, so he was obliged to tell the foreman the secret of the green glaze. This

* A pickle-leaf is an ornamental dish, in the shape of a leaf, to hold pickles.

secret soon spread to other works, and green pottery became the general manufacture of the district.

In 1760, Wedgwood went back to Burslem, and set up in business for himself at the Ivy Works. It was quite a small business, but the few men he did employ gave him a lot of trouble. They were used to the old slack, careless ways, but Wedgwood could not put up with them, nor with the dirt and muddle so common in pot works at that time. He determined to have method and cleanliness.

In spite of his lameness, Wedgwood was the life of the business. He did everything and was everywhere, and not only looked after all the branches of the work, but was the best workman in the place, making most of the moulds, preparing and mixing the clay, and acting as clerk and store-keeper as well.

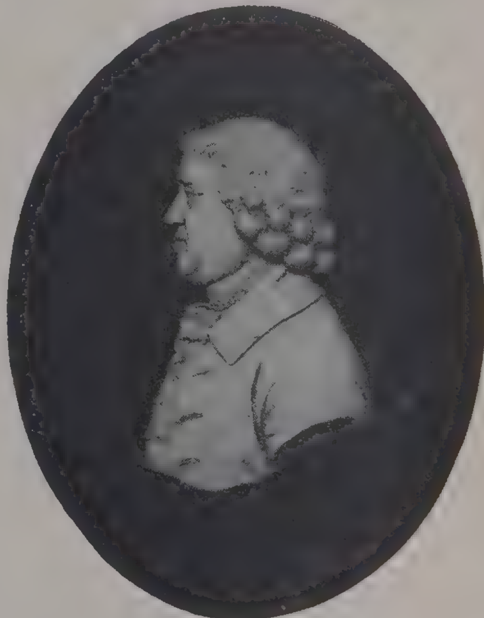
He could not afford to give up making ordinary crockery, but he could and did improve it. His plates were made in regular sizes, and could be piled up safely ; the teapot spouts poured ; lids fitted ; handles could be held. But Wedgwood looked forward to a time when he would be rich enough to make really beautiful things. He longed to decorate his ware with the flowers he loved so well. He worked hard, trying to find out better ways of " firing " (that is, baking) the earthenware ; he experimented also with other clays, and mixed different chemicals to make stronger glazes.

(*c*) The Queen's Potter.

Wedgwood's patience and hard work were rewarded with success. He had an engine lathe set up for smoothing rough surfaces, and in 1763 he invented a new kind of ware, fine yet strong, made from the white clays of Dorset, Devon, and Cornwall. The clay was mixed with a certain

proportion of finely powdered flint. The glaze was rich and brilliant, giving the ware a deep cream colour.

Wedgwood further improved his ware by the transfer of printed designs. He got the idea from a Liverpool printer, named Sadler. At first he sent his cream ware to the printing works at Liverpool to be decorated, but, before long, he bought up the right of making the transfers.



Josiah Wedgwood, from the medallion by W. Hackwood.
National Portrait Gallery.

In 1765, Wedgwood was delighted to receive an order from Queen Charlotte for a tea service. He spent much toil and care on the order, but was "teased to death," as he wrote to his brother, by drunken, idle workmen. One of his greatest difficulties was the uncertainty of fire. Often the work of a month was destroyed in an hour. Then the kiln had to be pulled down, and another built in its place.

At last the tea set was sent to Queen Charlotte, who was so very pleased with it, that she had it called "Queen's Ware," and appointed Wedgwood "Potter to Her Majesty." After this the cream ware sold rapidly.

Wedgwood was now able to carry out his wish to make beautiful things. He employed clever artists, carvers, and modellers to copy Greek and Italian pottery. Soon the Ivy Works were too small for the business, and he built new works at Etruria, a few miles away.

In 1766, another royal lady gave Wedgwood an order. This was the Empress Catherine of Russia. She wanted a set of "Queen's Ware," painted in black enamel, each piece with a different view of the castles and houses of the British nobility, and other places of interest in the British Isles.

The service consisted of 952 pieces, and took eight years to complete. The empress paid £3,000 for it; and though this sum scarcely covered expenses, she had given Wedgwood a splendid advertisement.

In 1768, Wedgwood was suffering so terribly from his diseased knee that it was found necessary to take off his leg. In those days this was a much more painful operation than it is now, but he bore the pain bravely. After a time he was hobbling about on crutches, for he could not get a wooden leg until he went to London. When he did get one, it was soon worn out, because he was so active. He always kept a few new ones in stock, and was delighted when he found that a modeller whom he had engaged was able to make wooden legs.

Wedgwood invented another kind of ware, "Jasper Ware." It had an unglazed ground of green, blue, or black with white figures and designs copied from Greek and other beautiful old carvings. He also made black basalt ware, with flowers enamelled in beautiful colours. In most of the museums you can see specimens of this great potter's work. One of his greatest successes was the copying of a famous Greek vase, known as the Portland vase, because it was at one time in the possession of the Portland family; and of this he made no fewer than fifty copies.

Josiah Wedgwood died in 1795. He had raised the craft of the English potter from a rude cottage industry to a fine art. He loved beautiful things, and he showed

how even ordinary earthenware could be made beautiful as well as useful.

Now let us turn to two men who helped Wedgwood in his work.

(*d*) Thomas Bentley (1731–1780).

For nearly twenty years, Wedgwood's greatest friend was Thomas Bentley.

Their friendship was the result of an accident. Wedgwood's business often forced him to journey to Liverpool on horseback, a painful undertaking on account of his lameness; and, on one occasion, passing through a narrow lane, he got his knee crushed in trying to avoid a cart coming towards him. He rode on, but when he reached Liverpool, he could not stand; and the result was that, for several weeks, he was laid up in bed at a Liverpool inn.

The doctor, wishing to cheer him, brought him a visitor, a gentleman of the name of Thomas Bentley. He was a Liverpool merchant, who had travelled a great deal, and knew several languages. The two men became great friends, and when Wedgwood was able to go back to Burslem in a carriage, they kept up their friendship by letters.

In all Wedgwood's difficulties, in his illness, and in his prosperity, Bentley was the one who helped him more than anyone else. He became the potter's agent in Liverpool, and saved him weary journeys. When the new works were opened at Etruria, Bentley became a partner, and later on, he took charge of Wedgwood's show-rooms in London. He was a handsome man with polished manners, and able to talk both French and Italian, so he was well qualified to receive the many English and foreign nobles who came to see the beautiful wares.

Bentley died in 1780, and Wedgwood was deeply grieved at the loss of his faithful friend and helper.

(*e*) John Flaxman (1755–1826).

A man who helped Wedgwood in a different way was John Flaxman, who became one of England's great sculptors.

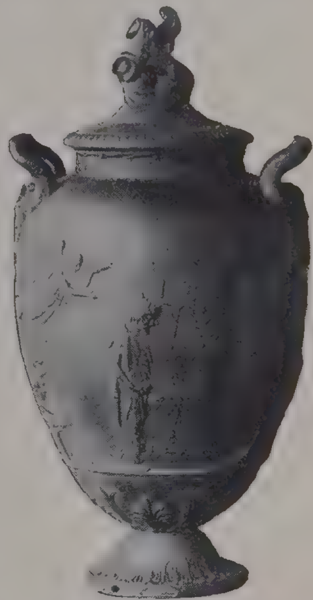
John Flaxman was the son of a London tradesman whose business was the making of figures in plaster of Paris. The boy was delicate and slightly deformed, and spent hours seated in a little stuffed chair behind his father's counter. If a customer came while his father was out of the shop, the boy got on his crutches and fetched what was wanted. At other times he was busy reading or drawing.

Many of the customers made friends with the little cripple. One gentleman gave him a book with translations of Homer's wonderful stories, and these tales delighted John so much that he made drawings and figures of the mighty Greek heroes, Ajax, Achilles, and the rest. Of course, they were not very good figures, but they were clever work for a little boy only eight years old.

As he grew older, John became stronger, and by the time he was ten years old he could walk without crutches. But he still worked at his drawings and models, which were now good enough to sell. When he was eleven, and again two years later, he won prizes from the Society of Arts for his figures in clay. In 1770, he won the silver medal of the Royal Academy. The next year he tried for the gold one.

Every one expected that he would win it, but the great artist, Sir Joshua Reynolds, who was the judge, gave it to another student, called Engleheart, who was never afterwards heard of. Perhaps this disappointment

was a good thing for young Flaxman; he may have been getting too self-confident. He felt he deserved the medal, but his defeat only made him the more determined to win. "Give me time," he said to his father. "I will yet do work that the Academy will be proud to own."



A Wedgwood Vase, with Flaxman's Modelling.
Victoria and Albert Museum.

About this time, Thomas Bentley, Wedgwood's partner, heard of the young artist, and recommended Wedgwood to give him some work. He did so, and Flaxman began to model vases and figures for the new jasper ware. He did some very beautiful work, perhaps the most beautiful being the figures of children playing at marbles, blind man's buff, and other games; these figures decorated some of Wedgwood's teapots.

For twelve years the young artist was almost dependent on his work for the potter, but in that time he managed to save enough money to go to Rome, where he spent seven years in studying sculpture. Although he was now able to get orders for figures and monuments in marble, he was still ready to help the friend who had first employed him, and he directed the work of designers whom Wedgwood sent to Rome.

When Flaxman returned to England, he was recognized as the greatest sculptor of the time. Perhaps the twelve years of work for Wedgwood, even if it were only the decoration of teapots and water-jugs, were preparing him for his future career as a sculptor; at any rate, they procured him the means of studying the art of sculpture in Rome.

Some of Flaxman's sculptures are to be seen in Westminster Abbey and in St. Paul's Cathedral, as well as in many churches up and down the land.

Questions.

1. In what ways did Josiah Wedgwood improve the pottery industry? How was his ware superior?
2. Describe some Wedgwood ware. Find illustrations from a chinaware catalogue, if possible. Give names of other kinds of ware, and find out where they are made.
3. How did two friends of Wedgwood help him considerably?
4. What is meant by the term, "potter's wheel"? Illustrate your answer.
5. Tell the story of the pottery industry, and of The Potteries.

8. HOW THE SLAVES WERE SET FREE.

(*a*) William Wilberforce (1759–1833).

The British Dominions.

There are many tropical parts of the world where the climate is too hot for white men to do very hard work. It may be possible to employ the natives, but sometimes they are not fitted for the tasks; then coloured labour, as we call it, has to be imported, that is, "coolies" or labourers are brought from neighbouring countries.

When Europeans first colonized America, they did not work their plantations by means of hired coolies; they bought negroes, who had been stolen away from their homes in Africa in order that they might be sold as slaves. People did not think it wrong in those days to buy and sell men, women, and children, just as we should sell cattle or horses to-day. Sometimes the slaves were treated well; often they were ill-used by their masters;

but the most terrible part of the business was the treatment they received on the voyage from Africa to America, often one-fourth of them dying before their destination was reached. Between the years 1680 and 1700, English traders exported no fewer than 300,000 slaves from Africa to the American colonies.

The first people to oppose slavery as contrary to the teaching of Jesus Christ were the Society of Friends, commonly called the Quakers. William Penn, who, in Charles II's time, founded Pennsylvania, "the Quaker State" of America, forbade the settlers to keep slaves.

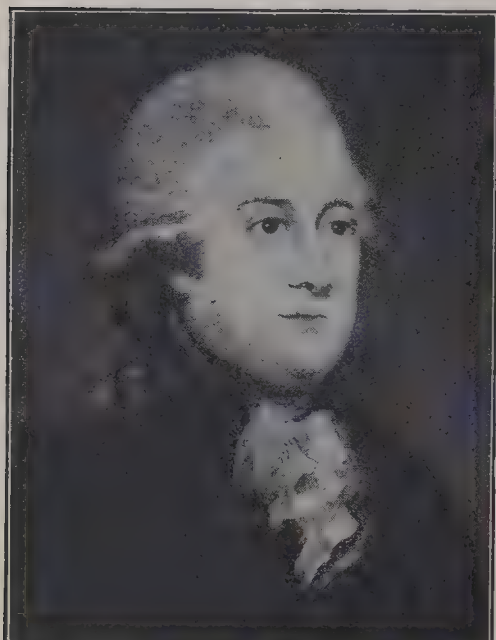
About a hundred years later, in 1787, a man named Thomas Clarkson became interested in the question of slavery. Meeting other men also interested in the question, Clarkson formed an Abolition Committee. This Committee needed someone to speak for them in Parliament, and they found their man in William Wilberforce.

William Wilberforce was born in the year that Wolfe won Canada (1759). He entered Parliament as member for Hull, when he was only twenty-one. Later he was elected for both Hull and York, and took his seat as member for York. William Pitt, the Prime Minister, was a college friend of Wilberforce's. One summer day, under an oak tree in the Prime Minister's garden at Holmwood (near Dorking, in Surrey), Wilberforce was talking with Pitt. Suddenly Pitt said, "Wilberforce, why don't you give notice of a motion to stop the slave trade? You have taken much trouble to collect evidence. It is a subject that would suit your talent."

Wilberforce was delighted at the invitation, and so were Clarkson and the other members of the Abolition Committee. The Prime Minister's friend was to take up the cause of the slaves, and they hoped for a speedy victory. But the West Indian merchants, ship-owners, and others

interested in the slave trade, immediately prepared to fight for what they called "the welfare of the West Indies, and the prosperity of Britain's trade on the High Seas."

During the next few months, Wilberforce was busy collecting all the information possible. In this he was greatly helped by Clarkson. One day Clarkson came to Wilberforce's house with a load of iron leg shackles, handcuffs, thumbscrews, and mouth-openers, which he had bought at a shop in Liverpool that was well patronized by slave-ship captains. The purchase had nearly cost Clarkson his life, for, one dark night, a gang of slave-traders had lain in wait for their enemy, and had nearly succeeded in throwing him into the dock.



Thomas Clarkson.

National Portrait Gallery.

Just when all was ready for the presentation of the Bill for the Abolition of the Slave Trade, Wilberforce fell ill. He was always a delicate man, and a great doctor declared that the champion of the slaves had but a few weeks to live. He was ordered to Bath, as there was just a faint hope that the healing waters might work a miracle. Before leaving London, however, Wilberforce managed to visit Pitt, the Prime Minister, and begged him to take his place as champion of the slaves. Pitt readily promised

to do so, and, cheered by this assurance, Wilberforce went to Bath.

Wilberforce did not die as the doctor had predicted. He slowly mended, and his recovery was hastened by the good news that a bill had been passed, in spite of great

William Wilberforce, from an unfinished painting by Sir Thomas Lawrence.

National Portrait Gallery.

opposition, limiting the number of slaves that could be carried on a slave-ship, thus lessening the over-crowding that had been such a terrible feature of the traffic.

After a time Wilberforce was well enough to introduce his motion for the abolition of the slave trade. The House of Commons was crowded to hear the member for York plead the cause of the slaves. For three and a half hours they listened spellbound to Wilberforce's expressive and beautiful voice, as he spoke of the cruelty and horror of the traffic in human beings. Many were convinced that Wilberforce was right, but the friends of slavery were

many and powerful, so the subject was set aside on the excuse of getting more evidence.

The battle was long and fierce. Nearly every year Wilberforce placed his Abolition Bill before Parliament, but every time he failed to get it passed, either because of the powerful opposition of his enemies, or because of the indifference of his friends.

Nine years after his first attempt, Wilberforce rose once more to introduce his bill against the slave traffic. When he had finished speaking, he was loudly cheered, and everyone knew that he was going to win at last. The bill was passed by a big majority, and the traffic in human beings ceased in the British Dominions (1807).

That was a great victory, but it was not all. There were still slaves, though no more men and women could be stolen away to be sold. The next step was to liberate all those who were still slaves in the British colonies.

Many other events, wars abroad, and political changes at home, prevented any further progress for many years. In 1823, a fresh society, the Anti-Slavery Society, was formed with the object of abolishing slavery throughout the British Empire, and Wilberforce and Clarkson were vice-presidents. Ten years later the Emancipation Act (1833) came before Parliament, by which the sum of £20,000,000 was cheerfully voted by an impoverished nation to be paid to the slave-owners for the slaves who were to receive their freedom.

Wilberforce did not live to see the fulfilment of his great desire—the liberation of the slaves—but he was cheered on his deathbed with the certainty that the reform he had worked for was soon to be accomplished.

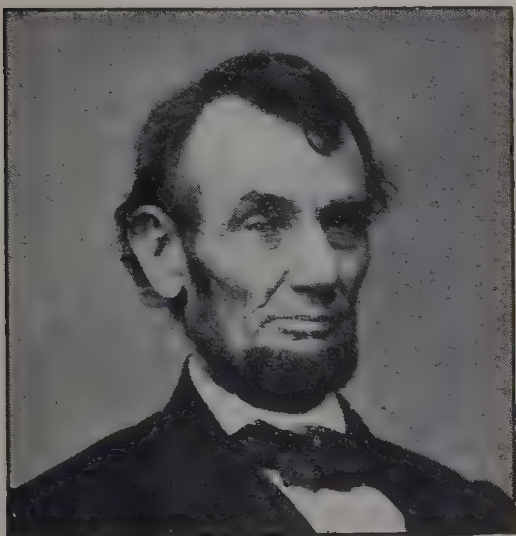
The Act was passed on August 30th, 1833, and within a few years slavery had ceased to exist in the British Dominions.

(*b*) Another Friend of the Slaves.

ABRAHAM LINCOLN (1809–1865).

The United States of America.

The question of slavery was one cause of civil war in the United States of America. In the Northern States all men were free; in the Southern States there were great tobacco and cotton plantations worked by negro slave labour, as they had been worked since the seventeenth century.



Abraham Lincoln. *E.N.A.*

In 1833, an anti-slavery society was founded in the north, with the object of abolishing slavery throughout the United States. In 1860, Abraham Lincoln, one of America's greatest citizens, and a man of strong anti-slavery opinions, became President. The Southern States—South Carolina, Mississippi, Florida, Alabama, Georgia, Louisiana, and Texas—at once decided to separate themselves from the Union, and form a Confederation of their own under the presidency of Jefferson Davis.

The Northern States declared they had no right to leave the Union, and it was to settle this question that the war was fought—not actually upon the question of slavery, although this was one of the chief causes of discontent, and it was known that if Lincoln and the

North won, slavery would be abolished altogether. But it was not until the last year of the war (1865) that the American Congress decided in favour of abolition, and the war was ended before the measure was actually made law.

After four years of war, the North won, and after the war slavery was abolished in America, as it had been in the British Empire some thirty years before.

Like Wilberforce, Lincoln did not live to see the fulfilment of his wish to set the slaves free. A few days before the war ended, he was shot by a madman in a Washington theatre.

9. THE STORY OF PRISON REFORM.

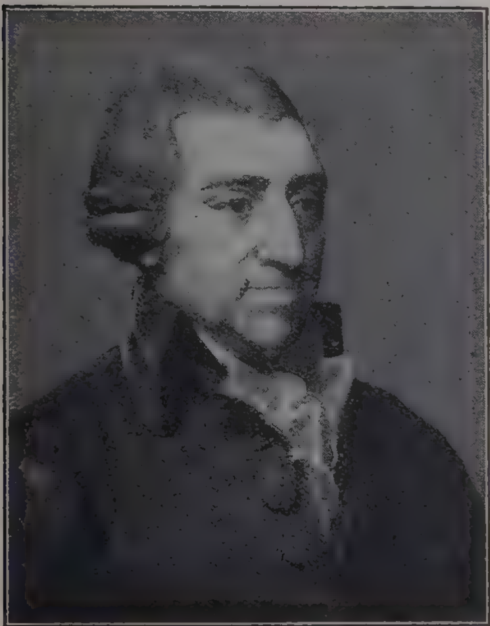
(*a*) John Howard (1726?–1790).

In the eighteenth and early nineteenth centuries many of the prisons of this country were overcrowded, partly because the ignorance and cruelty of the time produced a large crop of criminals, partly because the sentences passed were very severe.

In the prisons conditions were exceedingly bad. There was no regular allowance of food, the beds were of straw, and the buildings were dirty and unhealthy. The gaolers or turnkeys, as they were called, received no regular wages, but made what they could by the sale of drink and by forcing fees and bribes from the wealthier prisoners.

Adults and children were herded together, with no distinction between the hardened criminal and the boy or girl who had been caught in the act of some trifling theft. Children accompanied their mothers to prison, and shared in the misery.

The first man to call attention to the sad state of the prisoners was John Howard, a man of independent means who lived at Cardington, near Bedford. Howard was fond of foreign travel, and on one occasion the ship on which he was travelling was captured by a French privateer. Howard and the rest of the passengers, as well as the crew, spent some time in a French prison, at Brest.



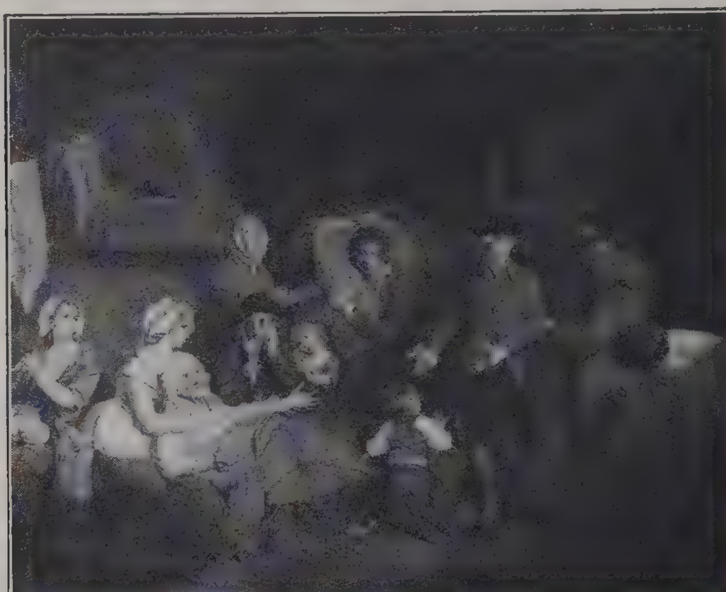
John Howard.
National Portrait Gallery.

Perhaps this experience made Howard very sympathetic towards other prisoners, for when, some years later, in 1773, he became High Sheriff of Bedford, he made use of this opportunity to visit the gaol. He was shocked at the condition of the prisoners, but he was equally shocked at the way the gaoler and his assistants extorted money from the prisoners in their charge.

Some prisoners, who had been declared not guilty by a jury, and others whose accusers had failed to appear at the time of trial, were still kept in prison, because they could not pay the fees demanded on their discharge. Turnkeys were known to have made quite large sums by charging the public a fee for the privilege of a peep at a notable prisoner.

Howard at once applied to the justices of the county for a salary to be paid to the gaoler, but he was asked if

he could name any other county where the gaolers were paid. He could not do so, but he determined to find out whether it was done. He visited county after county, and though he found no gaoler receiving a regular wage, he saw so much misery and ill-management in the



John Howard visits a prison. The relatives of the prisoner were often allowed to come and stay with him. They brought their food with them, or purchased it from the gaoler.

Photo.: W. F. Mansell.

prisons that he felt he *must* do something to bring about an improvement.

The following year he gave evidence to a committee of the House of Commons, describing what he had seen in the prisons, and was thanked for what he had done. Almost at once an act was passed which provided that all prisoners found not guilty by the jury should be set at liberty without delay, and free of all charges. A sum of money was to be paid to the gaoler from the county rates, to take the place of the fees. Another act passed

soon afterwards ordered the justices to see that the prisons were properly cleaned and ventilated, and that the walls were scraped and whitewashed at least once a year. Arrangements were also to be made for the proper care of sick prisoners in infirmaries.

Howard was anxious that no gaoler should be able to plead ignorance of this law, so he had copies of the act printed at his own expense and in large type, and a copy was sent to every gaoler and warder in the kingdom. Howard not only visited the prisons in England, but also travelled all over Europe for the same purpose.

(*b*) Elizabeth Fry (1780–1845).

John Howard died in 1790, and although some changes for the better had taken place in the prisons, there was still much to be done. The prisoners found another friend in a brave and good woman, Elizabeth Fry.

Elizabeth Fry was a Quaker lady, the wife of a London merchant. In 1813—while England was fighting Napoleon—she paid her first visit to the London prison, Newgate. She asked the governor to allow her to go into the women's wards, but he begged her not to do so, saying, "The women are so wild and fierce that, although soldiers are posted on duty, I myself never go into that part of the prison if I can avoid it." But Mrs. Fry was not to be turned from her purpose, and the governor took her to the women's wards.

The good woman never forgot her first visit to those wards. She found three hundred women and numberless children crowded into two small wards in charge of an old man and his son. They cooked and lived there, and at night slept on the floor. At the sight of the visitor they crowded around, demanding money, with which they would have bought drink. Mrs. Fry spoke

kindly to them, and promised to send some clothes for the many who were in rags.

Shortly after this a society was formed for the purpose of helping the prisoners, and Elizabeth Fry began to visit the prison regularly. At first the turnkey was almost afraid to shut her in with the women, as she asked him to do. She read to them one of the Gospel parables, and then talked to them about their children, for she saw that, rough and wild as they were, they still cared for their little ones. She asked them if they would like her to start a little school. The women were so touched by her kindness that they shed tears of joy, and begged her to do so.

Elizabeth Fry.
National Portrait Gallery.

Mrs. Fry went to the governor, and besought him to help her. At first he scoffed at the idea, but at last promised her the use of an empty cell as a schoolroom. When she next visited the women, she found that a young woman, Mary Connor, who was in prison for stealing a watch, was willing to help with the children. So the school was started ; Mary soon became quite a good teacher, and the children improved very much. Elizabeth Fry went every day to help with the school, but she wanted to do something for the mothers as well as the children.

She saw that the prison ought to do more than punish—it ought to teach the prisoners to lead a better life. She decided to teach the women, and set them to work. Having persuaded the prison authorities to help her in her plans, she explained to the women what she wanted to do. There was to be no more begging, swearing, gambling, or quarrelling; she was going to set up school for them as well as for their children. There would be classes under monitors, and they would be taught needlework, knitting, and other useful work. But they must promise to obey the rules that would be made. Every woman promised to do this, and an old laundry was turned into a workroom. Elizabeth Fry collected money to buy materials, and set the women to work under monitors whom they chose for themselves.

When the plan had been working about a month, the Lord Mayor and other gentlemen were asked to visit the prison. The visitors were amazed at the change that had taken place; for, in the courtyard, instead of a crowd of wild creatures, fighting and swearing and tearing one another's hair, all was peace and order. A tidy, well-mannered woman led them to a room in which they found Mrs. Fry seated at the head of a table. She was reading aloud to some of the prisoners who were engaged in needlework. Each woman wore a clean blue apron, and worked quietly, obeying the orders of the monitors.

Elizabeth Fry was now able to prove that her plan was working well, and she asked that there should be more room allowed for the women, that they should be looked after by women instead of men, that a proper allowance of food should be given them, and that they should be provided with decent clothing and useful work. She also proposed that they should have chaplains and teachers to give them religious and secular teaching. The

government was not able to grant these things all at once, but the methods introduced by Mrs. Fry at Newgate gradually extended to other prisons, and, as a direct result of her pioneer work, they have become part of the system for the care of prisoners to-day.

Elizabeth Fry reading to women prisoners in Newgate.
From the picture by Barrett. *Rischgitz.*

At that time hundreds of convicts, who had been sentenced to long terms of imprisonment, were transported, that is, sent across the sea to other lands. Before Britain lost the American colonies, convicts were sent to the plantations of Virginia; later, they were sent to the newly discovered lands of Australia and Tasmania. At Newgate, Elizabeth Fry heard terrible tales of the behaviour of the women before setting out for Botany Bay. The last night in Newgate was celebrated by smashing everything they could lay hands on.

But, with the coming of the Quaker lady, things had changed. The women listened quietly when she talked to them, promising to help them. That night there was no noise, and not a pane of glass was broken. Mrs. Fry went to the governor, and persuaded him to send the women to the docks in closed cabs, instead of in open carts, to be jeered at by unkind people, and cheered by their friends, if they had any. She had promised to go to the docks herself to see them, and there was no disturbance. Mrs. Fry, moreover, planned useful work under monitors for the long voyage, and wrote to the officials in Australia, suggesting ways in which the women might be helped to make good. For twenty-three years Elizabeth Fry visited every convict ship that sailed from England.

Like John Howard, Elizabeth Fry visited prisons in various European countries, and before her death, in 1845, her work was known and was being copied, not only in England and Australia, but in many of the countries of Europe. In 1824, new Gaol Acts were passed by which every prisoner had a separate bed; cleanliness was insisted upon; and chaplains, matrons, and teachers were appointed. Eight years later the death sentence for sheep-stealing and forgery was abolished, and by 1841 it was imposed for murder only.

At present the life in prisons is very orderly and healthy. Prisoners are employed on useful occupations, both in men's and women's prisons, and since 1918 great work has been done in many lands by the Penal Reform Leagues. Prisoners' Aid Societies do what is possible for discharged prisoners, and try to help them to make a fresh start in life.

Question.

Write a short account of the work of John Howard and Elizabeth Fry, giving the chief points in which their work differed.

10. LORD SHAFTESBURY—
The Friend of Children.
(1801–1885).

(a) Children in the New Factories.

With the invention in the eighteenth century of the new machines for spinning and weaving, great changes took place in England. They are known in history as the "Industrial Revolution."

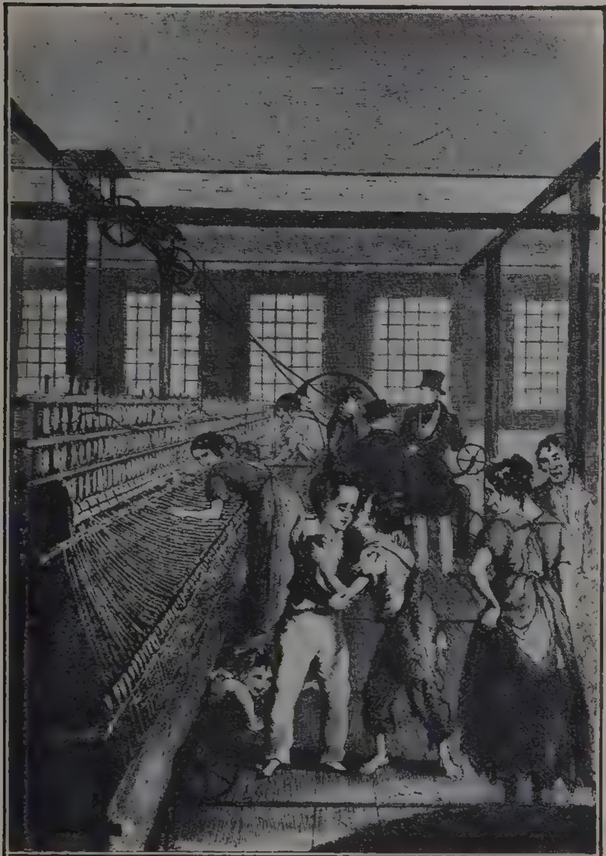
The new machines could be set up only in large buildings that were built for the purpose, as they required greater power than that of a man or woman to drive them. You will remember that the earlier machines were driven by water-power; but with the improvements in the steam-engine, steam-power came into general use. The use of steam demanded a greater supply of coal, and so it was cheaper to set up spinning sheds and weaving sheds in places where coal was most easily obtained. On this account big factory towns began to spring up in the north of England, where there were coal-pits.

The new mills and factories needed more and more machinery, and the iron-workers of the Midlands were using more and more coal in their great blast-furnaces. The old iron-works in Sussex, where, for centuries past, smelting of the ore had been done with charcoal, were now deserted.

Cottagers, who had been able to earn a large part of their living by spinning and weaving in their own homes, found that they could not compete with the new machines, and they were often forced to leave their homes in the villages to seek work in one of the towns. In this way, villages far from coal-mines often became practically deserted, while other villages near the mines suddenly grew into ugly, ill-built towns. But the saddest thing in

the story of the Industrial Revolution is the effect that it had on the children.

In the early eighteenth century Daniel Defoe, the author of *Robinson Crusoe*, made a tour through Britain, and he tells us that in the busy woollen districts there was not a child over five years old that could not earn its own living. But those children were usually in their own homes, helping their parents. When the machines were set up, it was found that much of the work could be as well done by children as by adults.



A Factory Scene. This illustration, taken from a book written in 1840, shows the condition of children who spent their very early years in a factory compared with those more fortunate ones who did not. It is also a good illustration of how the spinning mule had developed (*see chapter* 2(*e*).

Rischgitz.

At the close of the eighteenth century and the beginning of the nineteenth, there was much poverty in country districts owing to the industrial changes, and the long war with Napoleon had left many orphans to be provided for. So some mill-owners applied to the Poor Law authorities, especially those of London and the southern counties,

for child labour. Wagons full of children travelled to Manchester and other cotton towns. These children were bound to serve from the age of seven usually till twenty-one, and were entirely in the hands of the mill-owner, who clothed, fed, lodged, and worked them.

Poverty drove mill-workers to take their own children to work at a very early age, so in many a big mill there was quite an army of little workers. The apprenticed children rarely started work until they were seven, but the children of workers often started work at the age of three or four, earning sixpence a week for picking up "waste" from the floor.

The poor children often stood at their work twelve hours a day; some worked fifteen, and some even eighteen hours—for their hours were those usually worked by adults, and even for adults the working hours in those days were much too long. The work was carried on in hot, stuffy rooms, often by artificial light, which at that time meant oil lamps or candles; in some factories there were day and night shifts, so that the machines need never stop working. During meal-times and half-holidays children were often kept at work cleaning machinery. Besides all this, they were often beaten by the overseer, who used a long strap for the purpose of waking the poor little mites who fell asleep, or for punishing any carelessness.

Yet, even during this early and worst period of child labour, there were some good factory owners who employed children and young people under conditions unusually good for that time, and in these cases the children were much better off than they would have been in any eighteenth-century workhouse.

(*b*) Children in Mines.

If the lot of many little factory workers was hard, that of the children who worked in the coal mines was perhaps even worse. Tiny children, boys and girls, only four and five years old, were carried to the mines on their fathers' backs, acted as "fanners" working in inky

A boy hauling coal along passages sixteen to twenty inches high. Each wagon held from two to five hundredweights. From the Report of the Royal Commission on Mining, 1842.

darkness for sixteen and eighteen hours a day, and were then carried home, fed when they were almost asleep, and put to bed quite worn out.

Children of six worked as "trappers," sitting at doors in the mine galleries during a twelve hours' shift, ready to pull the door open to let coal trucks pass, and then close it again. At first they were given candle ends, which burned a couple of hours at the most. If the children cried or went to sleep on duty, they were severely beaten. Work in the pits began at four in the morning, and lasted till late afternoon or evening, so children working in the mines rarely saw the sunshine, except in summer.

As they grew older, these mine children were given still harder work. Boys and girls of ten or twelve, dressed alike

in short trousers and nothing else, acted as "drawers" and "thrutchers." The drawer-boy or -girl had a belt round the waist, and fastened to it was a chain attached to a coal truck, which was thus dragged through long galleries to the loading-stage. The thrutchers helped the truck along by pushing with their heads, while the drawers pulled. Thrutchers wore a thick cap, but the work soon made them bald on the top of their heads. The boys became miners when they grew up, but the poor girls had to go on working with the trucks.

(*c*) Lord Shaftesbury—the Friend of Children.

In 1802, an Act of Parliament was passed, forbidding the employment of *young* children *more than twelve hours a day*—excluding an hour and a half for meals, so the working day was really thirteen and a half hours. Another Act of Parliament forbade the employment of children under nine years of age in mills, though little boys and girls were still employed in the mines. But it was not until Lord Shaftesbury took up the cause of the children that much was really done for them.

Anthony Ashley Cooper, afterwards Lord Shaftesbury, was the son of a rich nobleman and heir to a title and great estate, but he had a very unhappy childhood. He was harshly treated by his father, who was often away from home, leaving the children to the care of the servants. His best friend was his nurse, who taught him his prayers and something of the love of God, but she died when he was quite young. Anthony's first school was a miserable place, where he was ill-treated and half-starved. But after he went to Harrow, life became better and happier.

While at Harrow, Anthony one day saw a pauper's

funeral. He shed tears of sympathy, and then and there vowed that, if ever he had the opportunity, he would do something to help the poor.

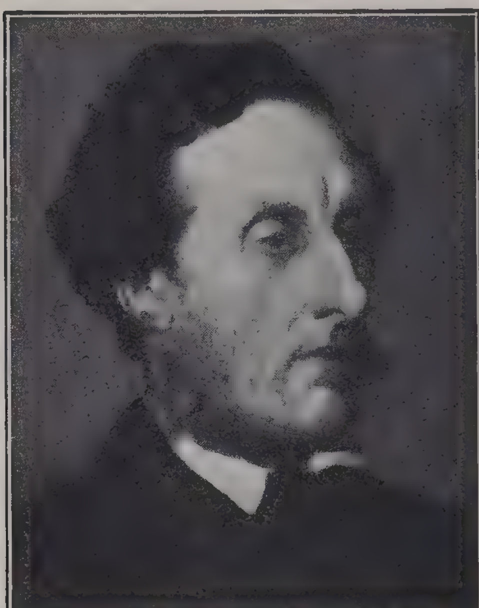
Perhaps it was partly because of his own unhappy childhood that the rich man's son was so eager to help the little boys and girls whose lives were so hard. When he grew up and became a member of Parliament, he brought in a bill to limit the children's working-day to ten hours. Even that meant working from six in the morning till half-past five in the evening, allowing time for meals, but up till then they had been working much longer.

Lord Shaftesbury, as Anthony came to be called, strove to make rich, comfortable people understand something of the hardships that children and adults were suffering almost at their doors. It took a long time to make them realize these things.

The most significant of the long series of Factory Acts beginning in 1819, was that passed in 1833, because this was the first to provide for the appointment of Factory Inspectors whose duty it was to see that the law was carried out.

Although Lord Shaftesbury spoke at meetings and wrote letters to the newspapers, he received but little attention when he first brought his Ten Hours' Bill before the House of Commons, in 1833—the year of the freeing of the slaves. He did not give up, however ; and, fourteen years later (1847), his bill became law. It was not until many years after that all the reforms that Lord Shaftesbury proposed were carried out ; but the Ten Hours' Bill was followed by a series of Factory Acts that gradually improved the conditions of workers—both children and adults—by laying down rules for work in factories, and appointing inspectors to see that they were carried out.

Meanwhile Lord Shaftesbury had been visiting the coal-mines. "It is easier," he said, "to talk after you have seen." What he did see was far worse than he expected. He demanded that the government should appoint a committee to hold an inquiry, and when the results of that inquiry were published, in 1842, there was, throughout the land, a general feeling of shame and anger, and laws were passed that made life easier for children employed in the mines.



Lord Shaftesbury.
National Portrait Gallery.

There was another class of children for whom this good man fought hard. In those days, when the old-fashioned chimneys were difficult to clean with brushes, it was the custom to make little boys, or even girls, climb up the chimney and get the soot down. If they were afraid and hung back, cruel master-sweeps sometimes lit a fire on the hearth and burnt their feet. They cut and bruised their poor little bodies on the sharp corners of bricks or stones as they climbed, and the soot poisoned their skins. Small children were needed for narrow chimneys, and some were sent chimney-climbing before they were five years old.

Thanks to the work of Lord Shaftesbury, this form of child labour is now unlawful, but it cost him a long and hard struggle before he won the victory.

There were still other children who were badly in need of a friend. In London there were streets and alleys where all sorts of wicked people lived ; people who made false coins, robbed houses and shops, picked the pockets of citizens in the streets, and sometimes even gagged and murdered unwary passers-by. The worst of these streets lay around Holborn Hill, and because so many people who were hanged at Newgate came from that district, it was called "Jack Ketch's Warren," from the name of the famous executioner.

In the midst of all this misery and wickedness, numbers of children were growing up, without any teaching or training, except in thieving and begging. Often there was no way of getting food except by stealing, and after they had played in the streets all day, they had no shelter for the night save a doorway or a dark archway. These children, already more or less vicious, were growing up to be vile and degraded men and women, just because they had no one to teach them to be different, and they never saw or knew anything good.

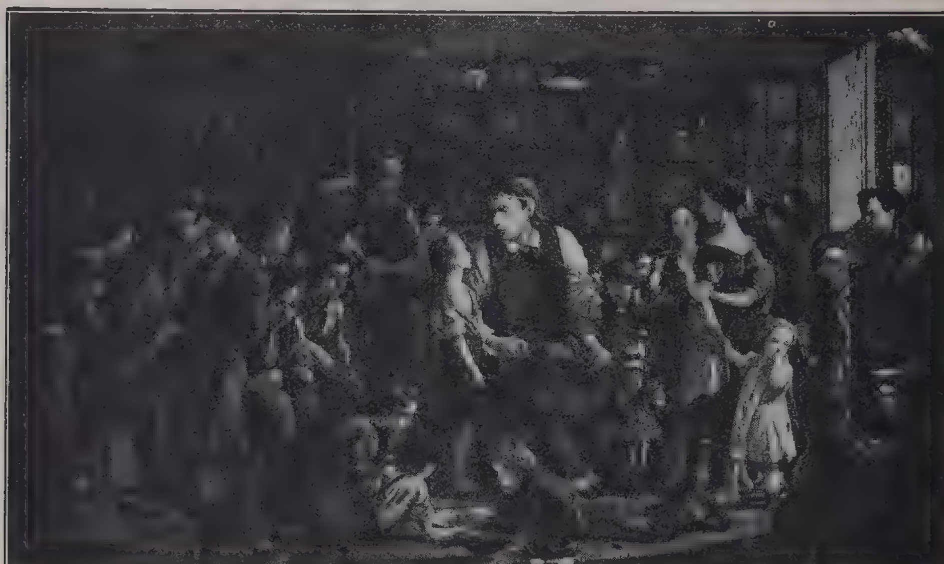
Some good and benevolent men, who were sorry for these poor children, started a little night-school for them. At first the boys behaved like wild beasts, fought and shouted, broke the chairs, knocked over the tables, and blew out the lights. But, after a time, they began to behave better and to try to learn a little.

By and by, Lord Shaftesbury heard of this little school. He went to see it, and visited it again and again.

By his help other schools of similar kind were set up, and the teachers went out at night to search for homeless children, whom they found in all sorts of odd places, and brought in for shelter and food. From this beginning came the Ragged School Union, or, as it is

sometimes called, the Shaftesbury Society, and the founder was its President for more than forty years.

Besides all this, Lord Shaftesbury took a great interest in reformatory schools, refuges, and working men's institutes ; in fact, there was hardly any kind of good work that escaped his attention.



Ragged School carried on by John Pounds, a cobbler.

Kischgitz.

Lord Shaftesbury died in 1885, at the age of eighty-four, and was buried in Westminster Abbey. Thousands of people lined the streets on the day of his funeral, every one of them wearing at least some scrap of black as a sign of mourning. There were boys from Ragged Schools, and from Homes and Refuges, old boys to whom these institutions had given a start in a respectable life, flower-girls and costermongers who knew and loved him.

There was still much left to be done, but Lord Shaftesbury had brought about many changes in the lives of the poor boys and girls who had so badly needed a champion.

11. GREAT ENGINEERS—STEAMSHIPS.

(*a*) JOHN FITCH (1743–1798).
ROBERT FULTON (1765–1815).

After the success of Watt's engines in driving machinery had been proved, men began to think of putting the new power to use on boats or ships. It often happened that ships would lie becalmed for days together, because there was not enough wind to fill their sails. At other times they would be blown out of their course, or were able to make little or no progress, because a gale was blowing against them.

As a result of experiments in England and America, boats driven by steam made their appearance in the early days of the nineteenth century.

One of the pioneers of steamboats, though himself unsuccessful, was an American, John Fitch, who was the son of a farmer in Connecticut. When he was seventeen, he went to sea; but, after a few voyages, he gave up his sailor life to become a clockmaker. That did not satisfy him, and he became a brass founder and then a silver-smith. After the American War of Independence, he undertook some inland exploration, and had many adventures, being captured by Indians and making his escape.

It was while sailing on the great western rivers that the idea struck him that steam might be used instead of oars or sails, to propel boats. On his return from the west he began to work out his idea. A small boat was built, and fitted with oars that could be worked by a steam-engine. A trial was made near Philadelphia, and the boat moved.

His next attempt was made on a larger boat. In 1787, he fitted upright oars along the side of a 45-foot vessel.

There were six oars on each side. The boat moved, but too slowly to please the inventor. Three years later he made a steamboat that carried passengers on the Delaware River. The boat travelled at the rate of eight miles an hour, but people were afraid of the new kind of boat, and the venture did not pay.

In 1793, Fitch went to France to try to get someone to help him with money for his inventions. He failed, and then came to England. As no one was ready to help him, he worked his way back to America on a sailing-ship, serving as a common seaman. After his return to America, he became so disheartened by his poverty and failures that in 1798 he committed suicide.

In a note-book he wrote these words :—" The day will come when some more powerful man will get fame and riches from my invention. But nobody will believe that poor John Fitch can do anything worthy of attention."

Fitch was right. Nine years later Robert Fulton took up the work, and made the first successful steamboat.

Robert Fulton was an Irish-American. He received a very scanty education, and was then apprenticed to a jeweller. He afterwards became a landscape and portrait painter, and managed to come to England to study. He became acquainted with the Duke of Bridgewater, James Watt, and others interested in engineering ; so he gave up painting to work at canal construction, and, in 1796, patented an improvement in canal locks.

From England he went to France. There he made the first submarine (under-sea) boat, the *Nautilus*, which was tried in Brest Harbour in 1801, in the presence of some of Napoleon's officers. The *Nautilus* succeeded in blowing up a small vessel moored for the test, but Fulton failed to convince either the French, English, or American governments of the value of his methods.

Returning to America, Fulton turned from explosives to steam. While in Paris he had made experiments with a sailing boat, and, in partnership with a friend named Livingston, had a steamboat built at New York. It was driven by paddle-wheels worked by one of Watt's engines. People who watched the boat being built called it "Fulton's Folly." The boat's real name was the *Clermont*.

The *Clermont* was launched in August, 1807. A crowd of people gathered at the water's edge, all sneering at the strange-looking vessel, and quite ready to laugh at it when it refused to go. But it *did go*. The engine was started, the big wide wheels began to turn, sending spray flying on all sides, and the *Clermont* was off to Albany.

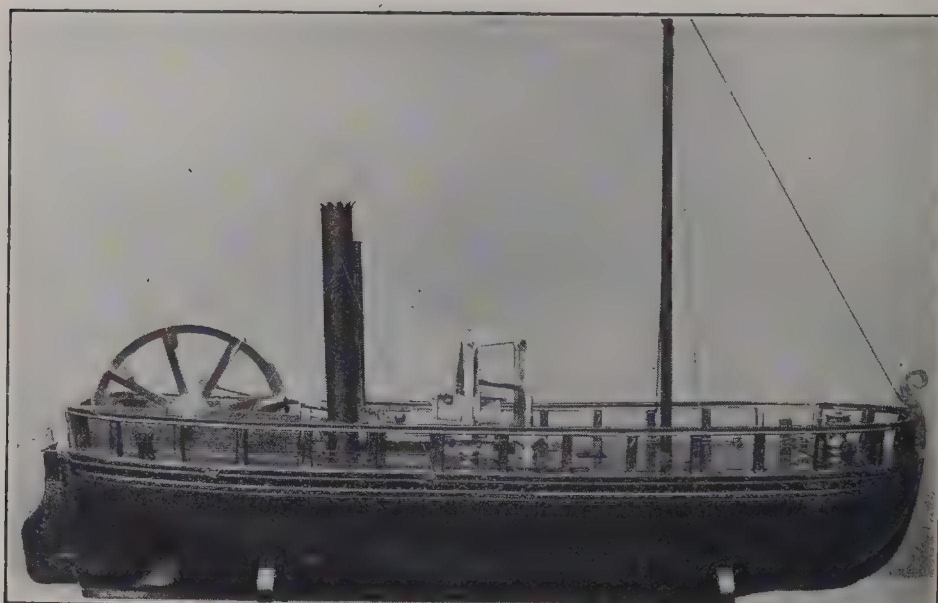
Only twelve persons took passage for Albany that day. Few men were bold enough to trust their lives, even on a river, to a boat with a boiler inside that might explode at any moment. The crews of sailing vessels gazed in astonishment at a vessel pouring out smoke and sparks, churning the water into foam, and moving without oars or sails. Some flung themselves on their decks in terror, others took to their boats and rowed ashore for safety.

The *Clermont* did the hundred and fifty miles from New York to Albany in thirty-two hours and returned in thirty hours, making about five miles an hour. She then made regular trips, and after a time proved a paying venture.

Just before his death, in 1815, Fulton made the first steam warship for the American government. It was a vessel of thirty-eight tons, with central paddle-wheels, and bore the name of the inventor.

(*b*) William Symington (1763–1831).
Henry Bell (1767–1830).

Even before the *Clermont* steamed along the Hudson, a steamboat, the *Charlotte Dundas*, had been tried on the Forth and Clyde Canal. It was built by William



Model of the *Charlotte Dundas*, 1802.
Courtesy of Science Museum.

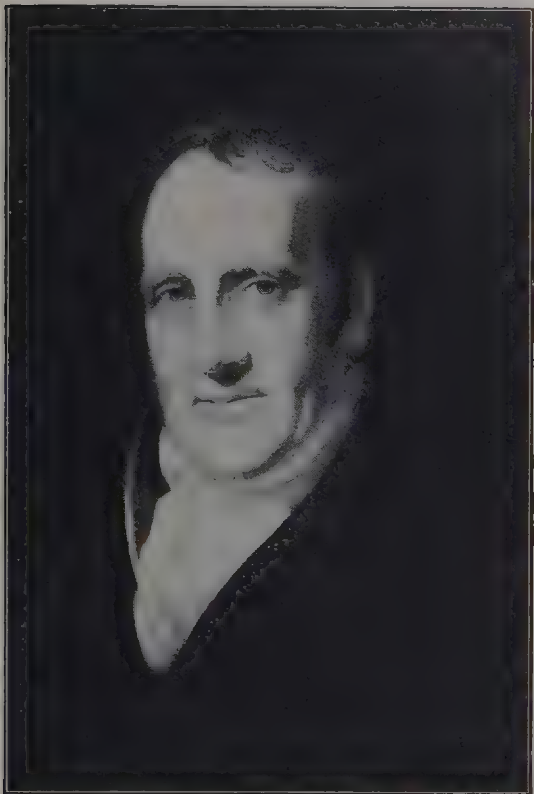
Symington in 1802, and was fitted with a revolving paddle-wheel worked by a Watt's engine. The trial was successful as far as the boat was concerned, but steam towing was given up for fear of injuring the banks of the canal.

Another Scottish engineer, Henry Bell, was working up the same idea. In 1801, he went to Watt for advice as to the use of steam in boats, but Watt was not interested in the subject.

"How many noblemen, gentlemen, and engineers," replied the careful James, "have puzzled their brains and

spent their thousands of pounds, and none of these, nor you yourself, have been able to bring the power of steam in navigation to any success!"

Bell was not to be discouraged. He worked at his plans, while earning a living by occasional engineering jobs. In January, 1812, he placed on the Clyde a steamboat which he named the *Comet*. It was of about twenty-five tons, and was driven by a 3-horse-power engine at the rate of seven miles an hour. It ran between Glasgow and Greenock.



Henry Bell
From a portrait in the *Science Museum*.

In 1814 London had her first steamboat plying on the Thames. Many people disliked the new boat. "This is a new experiment for the temptation of tourists," declared a writer of that time. "It was certainly very strange and striking to hear and see it hissing and roaring, foaming and spouting like an angry whale; but on the whole it rather spoils the scene, and I am glad that it is found not to answer, and is to be given up next year."

But steamboats were not given up. They were used on rivers and canals and for towing vessels out of harbour

in face of contrary winds. Soon they were used on the open sea.

(c) Steamships on the Ocean.

In 1819, twelve years after Fulton's steamboat puffed along the Hudson River, the first steamboat crossed the

Model of the *Comet*, the first steamship on the Clyde, 1812.

Courtesy of Science Museum.

Atlantic. It was called the *Savannah*, after the American port from which it started. The voyage from Savannah to Liverpool took twenty-five days. For such a long voyage it was thought too dangerous to depend entirely on steam, so the *Savannah* had sails as well as engines. Most of the time the sails were used, but now and then the clumsy paddle-wheels were set moving.

When passing the coast of Ireland, the *Savannah* was under steam. A British sailing-vessel caught sight of the smoke, and thought the American ship was on fire. Sailing to the rescue, the British crew discovered their mistake. They were invited on board the *Savannah*, and were greatly interested in the engine and paddle-wheels.

The first steamboats were all fitted with paddle-wheels, but although these were quite suitable for rivers,

they were not strong enough for the open sea. The paddles were easily smashed by great rolling waves, and then the vessel was disabled. For many reasons the use of steam in ocean navigation developed slowly, but it developed surely.

In 1825, the *Enterprise*, a vessel of four hundred and

The *Great Western*, the first vessel to cross the Atlantic entirely under steam, passing Portishead Point (North Somerset) on her first voyage to New York. Length 256 ft. Width 35 ft. Width over paddle-boxes 59 ft.
From a picture in the *Science Museum*.

seventy tons, made the voyage from London to Calcutta by way of the Cape of Good Hope in a hundred and three days. The ship was under steam for sixty-four days, and under sail for thirty-nine days. It was not until 1838 that the first ship crossed the Atlantic by steam-power alone; then the *Great Western* made the voyage in fourteen days.

In 1836, the invention of the screw propeller by an Englishman named Smith, and a Swede named Ericsson, enabled steam to be used to better advantage. But many changes had to take place in the building of ships before

steam vessels really took the place of sailing-ships. The machinery took up space, and the coal needed for fuel displaced cargo. When iron was used in the place of wood in shipbuilding, it was found that the iron affected the compass. But these difficulties were one by one

A modern liner, the *Queen Mary*.
Courtesy of Cunard White Star Limited. *Photo, Stewart Bale, Liverpool.*

overcome, and in 1883 the total tonnage of steamships equalled that of sailing-ships, while by the end of the nineteenth century it was four times as great.

Questions.

1. Who built the *Clermont?* Write what you know of its first trip.

2. Say what you know of two other early steamboats. What was the first steamboat to cross the Atlantic? When did it cross, and how long did it take?

3. Write a description of a modern liner, illustrating with pictures from a Steamship Company's booklet.

12. GREAT ENGINEERS—THE STORY OF THE LOCOMOTIVE.

(*a*) Stationary Engines and Locomotives.

Watt's engines (*see Chapter* 3) were used to lift coal from mines, to pump water, and to drive machinery. But the engine itself was fixed in one spot; it was a stationary engine. No one had yet succeeded in making an engine that would move itself on a level place and pull a load at the same time.

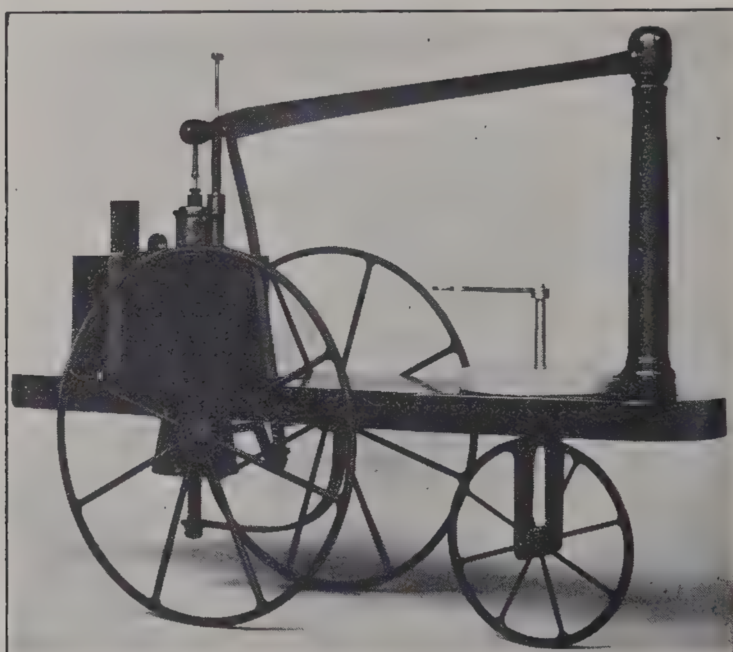
Soon after Watt's engines came into use, men began to think out a way of making the engines draw coal along the road from the coal-pit. They placed stationary engines short distances apart along the road. Each one pulled the loaded trucks up to it by a long rope. Then the trucks were unfastened from that rope, and fastened to another that pulled them on to the next engine. But such a plan was not generally used. In most collieries the trucks were drawn by horses, but rails were laid down for them to run on, because the roads were so uneven.

(*b*) WILLIAM MURDOCK (1754–1839).

Then men began to wonder whether it would be possible to make a locomotive, that is, an engine that *moves* itself from place to place. Even Watt himself, in his patent of 1784, had a plan for driving wheel carriages by steam. He never worked out the idea, though one of his assistants, William Murdock, tried to do so.

This young Scotsman was among those sent by Boulton and Watt to Cornwall to set up the Watt engines

in the Cornish mines. While at Redruth, in 1786, he began experiments on a steam carriage, or locomotive. He made a noisy, hissing little engine, and frightened the parson by driving it down the vicarage lane. His employers, however, gave him no encouragement.



Replica of Murdock's locomotive. Notice how very simple this first model was, and compare it with the pictures of engines of later date, but still early.

Courtesy of Science Museum.

Writing to Watt from Truro, Boulton said that on his journey to Cornwall, when near Exeter, he met a coach in which was William Murdock. "He said," wrote Boulton, "that he was going to London to get men; but I soon found he was going there with his steam carriage to show it and take out a patent. I persuaded him to return by the next day's coach."

"I wish William could be brought to do as we do," wrote Watt to his partner, "to mind the business in hand and let such as Symington and Sadler throw away their time and money in hunting shadows."

Murdock seems to have taken his employer's advice, for a little later Boulton wrote, "Murdock is in good spirits and good temper, and has neither thought upon nor done anything about the steam carriage, having so much to do about the mines. Send all engines as soon as possible, and he will be better employed than about steam carriages. He has made a pretty working model which keeps him in good humour, that is a matter of great consequence to us."

Murdock's "pretty working model," now to be seen in Birmingham Art Gallery, was a mere toy, but it could travel and carry its own fire shovel, poker, and tongs. After this attempt Murdock seems to have turned his talent in another direction.

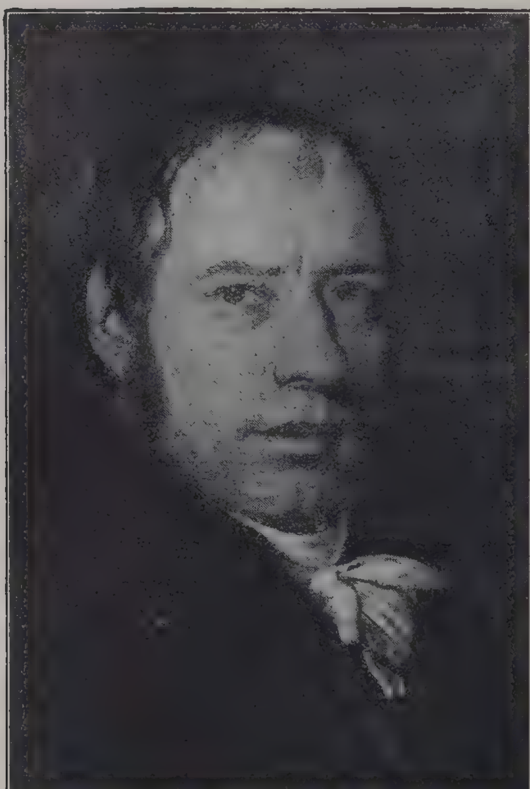
(*c*) Richard Trevithick (1771–1833).

Other men, both in England and in France, tried to make a steam engine that would move along. Some succeeded, as Murdock had done, in making one that would travel, but the roads were so bad that it soon came to grief. Then they tried to make it travel on rails, but here they met with a new difficulty. The wheels kept slipping when the steam turned them round. Sometimes the engine would move a little way, but then the wheels would slip, and it would stop. The man who made the first really successful road-engine was Richard Trevithick.

Trevithick was the son of the manager of a Cornish mine. He was born at Illogan, and attended school at Camborne. He was, on the whole, a slow and obstinate scholar, but showed some skill for figures. He grew up

tall and strong, and his feats in wrestling and in lifting weights were the wonder of the other lads in the neighbourhood.

When he was eighteen, he went to work in his father's mine. He soon showed his interest in machinery and his skill in invention, making improvements in the engine. Then he began to experiment with a locomotive engine in a carriage. On Christmas Eve, 1801, his road locomotive carried the first load of passengers ever conveyed by steam. The following year he applied for a patent.



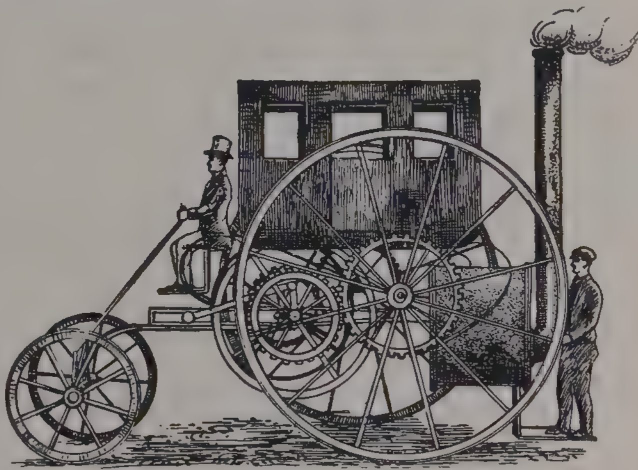
Richard Trevithick,
From a portrait in the *Science Museum*.

Trevithick's steam carriage was a strange affair. It looked like an ordinary stage-coach on four wheels. The engine with one cylinder was placed at the rear of the hind axle, together with the furnace box. It was fairly successful, and caused great excitement in the neighbourhood where it was built. On the road it caused terror and amazement, so that people called it the "Dragon."

Trevithick drove his steam carriage to the harbour, and shipped it to London. There he exhibited it, running

it through the streets from Leather Lane along Oxford Street to Paddington, and back through Islington. He soon gave up driving it, however, thinking no steam carriage would be a success on such bad roads.

Then he turned his attention to the construction of a tramroad locomotive. In 1804, he made an engine that would run on rails. It was used to draw trucks full of iron along a little railway at Merthyr Tydfil, in Wales. It drew a load of twenty tons at the rate of five miles an hour. That is only a little faster than a man can walk, but it was the beginning of *rail*-roads.


Richard Trevithick's Steam Carriage

Most people thought the idea of using steam to pull trucks was a very foolish one. Before long the weight of Trevithick's engine broke the rails, and it ran off into the road, so it was decided that horses were cheaper and better than steam. Then the wise folk laughed, and said, "I told you so!"

In 1808, Trevithick made a circular railway in London, near Euston Square, on which passengers were carried at the rate of twelve or fifteen miles an hour. Four years later, he brought steam into use in farming by making the first steam plough.

Shortly after this, he went to South America to set up engines in the mines of Peru. But, like many other inventors, Trevithick did not prosper. He returned to

England in 1827. The following year he appealed to Parliament for a reward for his inventions. He was refused, and died, penniless, at Dartford, in 1833, and was buried there at the expense of workmen at Hall's factory. And this was the end of "one of the greatest inventors that ever lived."

(*d*) William Hedley's "Puffing Billy."

The next step towards success was an engine with cogged wheels, patented by John Blenkinsop, the manager of the Middleton collieries, and used to haul coal along the tramway between the colliery and Leeds in 1811.

One of those who saw the first performances of Trevithick's steam carriage in London, was Mr. Blackett, the manager of Wylam colliery, in Northumberland. The Wylam wagon-way was one of the oldest in the north of England. Up to the year 1807, it was formed of wooden spars or rails, laid down between the colliery at Wylam, and the village of Lemington, some four miles down the Tyne, where the coals were loaded into keels or barges, and floated down past Newcastle, to be shipped for London.

Each wagon carried $1\frac{1}{4}$ tons of coal, and was drawn by a single horse. The rate at which the wagons were hauled was so slow that only two journeys were made by each wagon in one day, and three on the day following. Mr. Blackett was anxious to try the new idea of a locomotive, and ordered an engine. The first engine was a very clumsy thing; it was got upon the road after much difficulty, but then refused to go.

Its maker, Tommy Waters, became impatient, and then angry, and, taking hold of the lever of the safety valve, declared that either *she* or *he* should go. *She* went, but not in the way her maker intended. She blew into pieces as soon as the machinery started.

But Mr. Blackett was not discouraged. He ordered another engine, and this was a little more successful. It could drag eight or nine loaded wagons, but it moved at the rate of only one mile an hour, and sometimes

"Puffing Billy," the oldest locomotive in existence. It was constructed at Wylam Colliery in 1813 by William Hedley, and worked there till 1865.
Courtesy of Science Museum.

took six hours to do the journey of five miles. Its weight was too great for the road, and although cast-iron plates were used in place of the old wooden rails, they were constantly breaking. It was apt to get off the rail, and then it stood still.

The driver was one day asked how he got on. "Get on?" said he. "We don't get on; we only get off!" On such occasions, horses had to be sent to drag the wagons as before, and others to haul the engine back to the workshops. At length it became so cranky that

horses were usually sent after it to drag it along, when it gave up ; and the workmen declared it to be " a perfect plague."

Among the workers at the colliery was a clever man called William Hedley. He had been of great help to Mr. Blackett in the engine tests, and he felt sure there must be a way of making the engine keep to the rails. He made various experiments, and found that the weight of the engine, if sufficient, would do this, even if smooth wheels were used on smooth rails.

He made a new engine, and it worked well, although it had one great fault. It made a fearful noise that frightened men and horses. Wylam road was at that time a public highway, and one gentleman threatened to have the nuisance stopped. In order to save trouble, Mr. Blackett told the driver that as soon as any horse, or vehicle drawn by horses, came in sight, the locomotive was to be stopped, so that the frightful puffing might not frighten the animals. This caused much delay to the working of the railway, and the workmen grumbled.

Some improvements were made, and " Puffing Billy," as this noisy locomotive was rightly called, carried on its work of hauling trucks for nearly fifty years. While Hedley was busy with " Billy," another engineer was making trials at the neighbouring colliery of Killingworth. This was George Stephenson.

Questions.

1. Tell the story of William Murdock; and that of Richard Trevithick.

2. Why was " Puffing Billy " so called? Why is it important in the story of the locomotive? Describe it from the picture on page 121.

13. GREAT ENGINEERS—THE BEGINNING OF RAILWAYS.

"The Father of Passenger Railways"
GEORGE STEPHENSON (1781–1848).

Railways and Railway Bridges
ROBERT STEPHENSON (1803–1859).

(*a*) A Collier Lad.

George Stephenson, the man who planned the first passenger railways, was born in a little cottage near Wylam colliery, where his father was fireman of an engine. The wagon-way by which the coal from Wylam was hauled to the Tyne passed the cottage, and as George was the second of a family of six children, one of his earliest duties was to keep the other children out of the way of the wagons. George's father, "Old Bob," as he was called by his neighbours, earned only twelve shillings a week, so there was little money to spare for clothes, and none for schooling.

When George was eight years old, his father moved to Dewley colliery, and George himself started work. A widow, who lived at a farm near by, kept a number of cows. She was allowed to graze them along the wagon-way, and needed a boy to herd them, and keep them out of the way of the wagons. George applied for the job, and, to his great delight, was engaged at the wage of twopence per day.

It was easy work, and he had plenty of spare time on his hands, which he spent in bird's-nesting, and in building little mills on the tiny streams that flowed into Dewley bog. But his favourite pastime was making model engines; he used clay from the bog, and fitted in stalks of hemlock for the steam pipes.

A little later, he was set to lead the horses when ploughing, though he was scarcely big enough to stride across the furrows. He was also employed to hoe the turnips and do other farm work, for which he was paid higher wages—fourpence a day. But George did not mean to be a farm labourer; he wanted to work at the colliery, and he soon joined his brother James as a picker, to clear the coal of stones, bats, and dross. His wages were sixpence a day, but when he was set to drive a gin (engine) horse he got twopence a day more.

When George was fourteen, he became assistant fireman at a shilling a day; but, soon after this, the coal was worked out, and the Stephenson family had to move again to "follow the work." George and his father got work at Newburn, "Old Bob" as foreman, and George as plugman to watch the pumping engine.

The lad loved his engine, and on Saturday afternoons, when the other lads were playing football on the common, he would shut himself in the pumping room and clean his engine, carefully examining each part. In this way he found out many things about machinery, and soon began to make little inventions for himself. Next to engines, George loved horses, and whenever he could get the chance he had a ride on one of the gin horses.

George was now seventeen, but he could neither read nor write. He was delighted when he could get someone to read to him from any book or stray newspaper that came that way. Napoleon was at that time overrunning Europe, and no one was more interested in the exploits of the great conqueror than the young engine-man at Water-row Pit. But George was not satisfied with listening to someone else; he wanted to read for himself, so that he might find out more about engines and the uses of steam, and more about Napoleon as well.

His first schoolmaster was Robert Cowens, the teacher in a neighbouring village school. Cowens kept a night school, which was attended by a few colliers' and labourers' sons. George took lessons in spelling and reading three nights a week, for which he paid threepence a week. He also practised writing, and by the time he was nineteen he was proud to be able to write his own name.

Then a Scotsman set up a school in Newburn, and as he was said to be a good arithmetician, George started lessons with him at the fee of fourpence a week. He soon outstripped the other lads, and was doing reduction sums while they were still struggling with addition and subtraction. He worked out his sums while seated by the engine fire, and took them in the evening to be marked; fresh ones would then be set.

In 1801, Stephenson became brakesman at Willington, and about the same time he married. His only son, Robert, was born in 1803. From Willington Stephenson moved to Killingworth, where he was appointed enginewright in 1812 at a salary of £100 a year.

He was determined that his son should have proper schooling, and, being a poor man, he set to work, while Robert was still a baby, to save money for his school fees. He made use of his spare time to mend watches and clocks for his neighbours, to make lasts for shoemakers, and to cut out clothes for his fellow pitmen. In this way he managed to save £100. In 1815, Robert, who was twelve years old, was sent to a school in Newcastle. His father bought him a donkey, and on this he rode off every morning, in his rough grey suit cut out by his father, with his bag of books and his dinner slung over his shoulder. Father and son had always been great chums, and George made the boy's education a means of increasing his own knowledge.

(*b*) Stephenson's First Engine.

George Stephenson was greatly interested in Hedley's "Puffing Billy." He often went over to Wylam to see how the trials were going on, and after one of his visits he declared that he could make a better engine than "Billy."

He had no money to spend on engine making, but when he spoke of his idea to the owners of Killingworth colliery, they were interested. They had already seen what a good workman Stephenson was, and how many improvements he had made in the colliery engines, so they agreed to let him have the money to make a "travelling engine."

Stephenson set to work, and the engine was placed on Killingworth railway in July, 1814. It managed to draw eight loaded trucks of thirty tons weight up a slope at the rate of four miles an hour. This engine was known as "Blücher," in honour of the Prussian general then helping the Duke of Wellington against Napoleon.

(*c*) Stephenson's First Railways.

While Stephenson was making engines at Killingworth, the people of Stockton and Darlington were talking of making a canal to carry coal from Stockton to Darlington. Other people thought a horse railway would be better than a canal. The owners of donkeys engaged in carrying coal, as well as the turnpike trustees, were against the canal, and the Duke of Cleveland was afraid the railway would spoil his fox-hunting.

When George Stephenson heard this, he thought it a pity to use horses on the railway now that steam could be made to do the work; so he went to Mr. Pease, one of the gentlemen interested in the railway, and suggested that locomotives should be used instead of horses.

"Come over to Killingworth," he said, "and see what my engines can do; seeing is believing, sir."

Mr. Pease went to Killingworth, and saw the wonderful machines that were to take the place of horses. He was so pleased that he had the Stockton and Darlington Railway Act altered to allow locomotives to be used,

The first engine built (by R. Stephenson & Co., in 1825) for the Stockton and Darlington Railway. It ceased running in 1846 and is preserved at Bank Top Station, Darlington.

Courtesy of Science Museum.

and passengers to be carried as well as goods. George Stephenson was appointed engineer.

In September, 1825, the first real railway was opened. Although many people thought it would be a failure, great crowds came together to see the first train. Stephenson himself drove the engine. In front rode a man on horseback carrying a flag. When a good stretch of road was reached, Stephenson shouted to the horseman to get out of the way. Then he put on steam, and the speed of the engine rose to twelve miles an hour, and in some places to fifteen miles. But this was just to show what

could be done. The actual journey between Stockton and Darlington, a distance of twelve miles, took two hours.

The locomotive driven by Stephenson on that journey, "Locomotive No. 1," is still to be seen in Bank Top Station, Darlington.

When the Stockton and Darlington Railway proved

Model of the first passenger carriage used on the Stockton and Darlington Railway. It was similar to an ordinary coach. The body was mounted on a four-wheeled underframe without springs.

Courtesy of Science Museum.

successful, the merchants of Manchester and Liverpool began to think that they might find a railway cheaper than the canals, for the canal companies did their work in a sleepy, stupid manner, and charged what they liked.

George Stephenson was asked to undertake the work, but he had great difficulty in making his survey and taking measurements. Many of the farmers and landowners did not want the railway, and when they found Stephenson and his men on their land, they drove them away; in one case at least, the engineer and his helpers were attacked with a pitchfork.

When it was decided to ask Parliament to pass a Bill

George Stephenson, from a portrait in the *Science Museum.*

permitting the railway, one of the lawyers advised Stephenson to keep his engine within reasonable speed, or the whole thing would be ruined. Stephenson had dared to suggest that his locomotive could travel twenty miles an hour, double the speed of the swiftest stage coach.

Many people were still quite certain that no good would come from railways. They said the engine would blow up; the wheels would fly off; sparks would set fire to houses and ricks; the wind and rain would put out the fire, and stop the engine; horses and cows by the railwayside would die of fright.

The *Tyne Mercury* was very much against railways. "What person," asked the editor in 1824, "would ever think of *paying anything* to be conveyed from Hexham to Newcastle in something like a coal wagon, upon a dreary wagon-way, and to be dragged for the greater part of the distance by a ROARING STEAM-ENGINE?"

A few years later, when the Liverpool and Manchester railway was being talked of, a well-known magazine published an article which, though in favour of the railway, had no faith in great speed. "What can be more absurd," the writer asked, "than the idea of travelling twice as fast as stage coaches? We would as soon expect people to be fired off on one of Congreve's rockets . . . We trust that Parliament will limit the speed to *eight or nine miles an hour*, which, we believe, is as great as can be ventured with safety."

A Committee of the House of Commons met to inquire about the railway, and Stephenson was asked many questions.

"Suppose, now," one of the Committee asked, "one of the engines to be going along a railroad at the rate of nine or ten miles an hour, and that a cow were to stray

upon the line, and get in the way of the engine: would not that be a very awkward circumstance?"

"Yes," replied Stephenson, with a twinkle in his eye, "very awkward——for the *coo!*"

Another member asked if animals would not be frightened by the engine, especially by the glare of the red-hot chimney. "But how would they know it wasn't painted?" was the reply.

When the Bill was passed, there was an even worse difficulty to be faced. The railway had to cross a bog, known as Chat Moss. The cleverest engineers of the day declared that this bog would never be made firm enough for a train to pass over it. But Stephenson was not to be daunted.

He set hundreds of men and boys to work cutting away the moss. This was dried and used to build an embankment. The bog was drained and filled in, filled in and drained, until at last it was firm enough to carry the railway track.

While this work was going on, all kinds of wild tales were carried into Manchester by the drivers of the stage coaches. Now it was, "Chat Moss is blown up!" Again, "Hundreds of men and boys have sunk in the bog! The work is being given up!" Or, "Stephenson has been swallowed up in Chat Moss! That finishes railways!"

(*d*) The "Rocket."

When the railway track was nearly finished, the railway company offered a prize of £500 for the engine that could draw a weight of twenty tons at ten miles an hour, and not cost more than £550.

A well-known Liverpool gentleman declared that these conditions could never be fulfilled. "It has been

proved," he said, "that it is impossible to make a locomotive engine go at ten miles an hour, and if it is ever done, I will eat a stewed engine wheel for my breakfast."

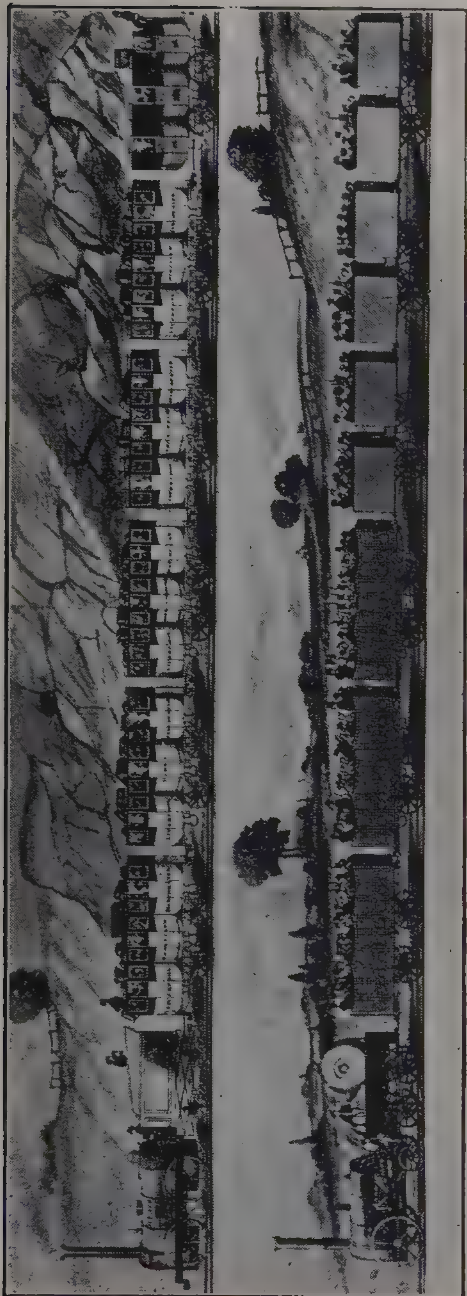
In October, 1829, the trial took place on a level part of the track at Rainhill. Three engines were entered, including one built for Stephenson at the engine works

The *Rocket*, the engine, built by George Stephenson, which won the £500 prize in the competition at Rainhill in October, 1829.
Courtesy of Science Museum.

he had set up at Newcastle. It was called the "Rocket." Two of the engines broke down during the trial. Only the "Rocket" passed all tests, and gained a speed of over thirty miles an hour; so Stephenson won the prize.

The Liverpool and Manchester Railway was opened in September, 1830. Eight locomotive engines made at Stephenson's works were placed on the line. The "Northumbrian" driven by Stephenson himself, headed the line of trains; other engines were driven by his son and by his brother.

After the opening of the Liverpool and Manchester Railway, men began to see that railways and locomotives were useful after all; and, in the following twenty years, railways were begun in all directions. So many railway



Photographs of early trains on the Liverpool and Manchester Railway. The upper picture shows first class carriages, the lower second and third class. Notice that the guards sat outside, and that the luggage was carried on the top of the coaches. Wealthy people who preferred to do so could have their own coaches placed on flat wagons, and ride in them.

Courtesy of L. M. S. Railway.

companies were formed, and formed in such a hurry, that they were bankrupt before their lines were finished. Many people who borrowed money to buy railway shares were ruined.

George Stephenson himself had no sympathy with this "railway mania," as it was called. He went on quietly with his work of making railways in England, and also visited Belgium and Spain to give advice about railways in those countries.

(*e*) Robert Stephenson (1803–1859).

In 1840, George Stephenson retired from active business, leaving his son Robert to carry on. He spent the last few years of his life at Tapton House, Chesterfield, where he died in 1848.

Robert Stephenson

fully repaid the sacrifices his father made in order to give him a good education. He left school at the age of sixteen, and was apprenticed to Nicholas Wood, a coal viewer (i.e. overseer) at Killingworth, after which he went to Edinburgh University to study science.

He worked with his father on the Stockton and Darlington Railway, and also on the Liverpool and Manchester; but, in 1824, as he was in bad health, it was decided that he should take a post in South America, and he remained there for three years.

When he was returning to England, he had to wait at Cartagena for the ship on which he was to sail. In the hotel he noticed a tall gaunt Englishman, shabbily dressed and evidently very poor. He asked who he was, and found that he was Richard Trevithick, the maker of the first steam carriage. He was returning to England from the mines of Peru, penniless. Robert lent him £50 to help him on his way home.

Robert Stephenson settled down at his father's engine works, and superintended the building of the "Rocket." Later on, he made an engine of his own, called the "Planet," which became the model of the engines of to-day.

While the Liverpool and Manchester Railway was being made, it was decided to make a short railway between Leicester and Swannington, thus joining up the former town with the coalfields in the western part of the county. George Stephenson was asked to do the work, but he was too busy with the thirty miles of railway he had in hand. Then he was asked if he knew an engineer who could do it. "Well," he replied, "I think my son Robert is fit to undertake it." So Robert Stephenson, at the age of twenty-seven, began his first railway.

In 1832, a Bill was applied for to cut a railway from

Robert Stephenson, from a portrait in the *Science Museum*.

London to Birmingham, and Robert Stephenson was appointed joint engineer with his father.

Within a few years the opposition to railways had given place to the "railway mania." In 1840, 1,330 miles of railway had been made; in 1850, the mileage had been increased to 6,635 miles; and, ten years later, to 10,410 miles. The length of British railroad is now about 20,000 miles.

The extension of railways made it necessary to build bridges of a kind very different from the old bridges that had served the roads. Iron was now used in bridge-building, and Robert Stephenson may be called "the father of the modern bridge." When he carried out the Newcastle and Berwick Railway, no fewer than 110 bridges of all sorts, some over the line, some under it, had to be made. The greatest of these was the Royal Border Bridge across the Tweed at Berwick.

Another of Robert Stephenson's bridges spans the Tyne at Newcastle, and is known as the High Level Bridge. But, perhaps, the most interesting of all his bridges is that which carries the railway across the Menai Strait to the island of Anglesey. It is made of two huge tubes of iron, each 1,511 feet long, and each weighing 4,680 tons.

The tubes rest on five towers, the centre one of which is built on a rock in the middle of the strait. The work of building this bridge was very difficult, and cost the builder many sleepless nights. It was not only a triumph for Robert Stephenson; it was a triumph for the "New Iron Age," for without the steam engine, and the improvement in the manufacture and quality of iron, the design could not have been carried out.

Stephenson built other tubular bridges, one at Conway, two over the Nile, and one, the Victoria Tubular Bridge,

across the St. Lawrence at Montreal. The Victoria Bridge was begun in 1854, and took five and a half years to build. The first train passed over the bridge in December, 1859; but its designer had died two months before. He was buried in Westminster Abbey, by the side of Telford, the designer of the Menai Suspension Bridge.

The Britannia Tubular Bridge, across the Menai Strait.

E.N.A.

Both George and Robert Stephenson were offered knighthood, but refused it. Both of them were kindly, generous men, and never forgot their old friends in the colliery villages, who still remained poor and unknown while the Stephensons rose to fame.

But their fame was the result of hard work, patience, and perseverance. Had Trevithick possessed these qualities, he might have won the honour which his successors gained.

Questions.

1. Write what you know of the following:—the "Dragon," "Puffing Billy," "Blücher," and "Rocket."

2. When was the first passenger railway opened, and where did it run? What was the speed reached? Describe the opening.

3. What was the first piece of work that Robert Stephenson did in connection with railways? What other engineering work did he accomplish?

4. What two branches of engineering work were done by Telford?

5. Give the names of the chief railway systems in England to-day. What is the mileage? Illustrate your answer with a map showing the main lines.

6. What improvements have there been in methods of transport and travel in your own neighbourhood within your memory?

7. What is the rival of the railways to-day? Why?

14. PIONEERS OF GAS LIGHTING.

(*a*) Doctor Clayton.
Lord Dundonald (1749–1831).

At the close of the seventeenth century, a clergyman, Dr. John Clayton, Dean of Kildare, who was fond of making experiments, found that a certain gas could be made from coal. Having made the gas, he filled some bladders with the strange invisible thing. When he pricked the bladders and applied a spark, the escaping gas burned, giving a bright light.

During the eighteenth century, other men made experiments with coal-gas, and tried to use it in various ways. Some found it useful for filling balloons, others managed to make it work little engines.

Lord Dundonald, a Scottish nobleman, who spent all his fortune on scientific inventions that other people laughed at, made gas while experimenting with coal for the purpose of making tar and oil. He even used the

gas for lighting the hall of his house, Culross Abbey. But it was not until the nineteenth century that gas as a means of lighting actually came into use.

(*b*) William Murdock (1754–1839). Frederick Winsor (1763–1830).

The man whose experiments led to the first attempts to make gas on a large scale, was William Murdock, of whose work in connection with steam locomotives you have already heard.

When William went to Redruth, in Cornwall, in 1792, to set up some more of Watt's engines in the Cornish mines, he found time to try experiments with coal gas. He seems to have given up the idea of making steam carriages. It is said in Cornwall that a millwright named Hornblower first suggested to Murdock the idea of making gas; but, as we have seen, the possibility of making gas had been known for at least a century.

However, Murdock made experiments, and was so successful that he used gas for lighting his cottage and his office. In 1799, he returned to Birmingham, where he continued his experiments in the storage and purification of gas. In 1802, when England celebrated the Peace of Amiens with Napoleon, a part of the outside of the Soho factory was illuminated by gas. Next year, gas was used for lighting the inside of the building.

Murdock's first plan was to burn the gas as it escaped from the open end of a small iron tube, but he soon found this to be a very wasteful method, using a lot of gas, and giving very little light. Then he closed the end of the tube and bored three little holes in it, making the so-called "cockspur" burner, which gave three little jets of flame. Then a sawcut was made instead of the holes, giving the "batswing" burner. This was replaced

by a two-hole burner, the "fishtail," which was in general use till the invention of gas-mantles.

While Murdock was making his experiments in England, men on the Continent were doing the same thing. A Frenchman, named Lebon, took out a patent in Paris for making gas that could be used for lighting purposes. He prepared it from wood. A German, Frederick Winsor, offered to buy the secret, but he was refused. He then went back to Germany, determined to find out for himself how gas was made. He soon learned the secret, and made gas from coal as well as from wood.

A lamplighter in olden days. Notice the can of oil that the boy carried. For many years gas lamps were similarly lit from a ladder, lucifer matches being used in place of flint, steel, and tinder-box.
Rischgitz.

In 1804, Winsor came to London. He gave lectures and performed experiments to show that gas might be used for general lighting purposes. The clever men of

the day would not believe this. Sir Humphry Davy, the great chemist, laughed at him. Sir Walter Scott, the famous poet and novelist, wrote that a madman was talking of lighting London with—smoke. Winsor, however, was sure of his own idea, and began to raise money to form a Gas Company.

In 1805, the *Morning Post*, a London newspaper, told its readers that a shop at the corner of Piccadilly "is illuminated every evening with gas. It gives a much more brilliant light than either oil or tallow."

Two years later, gas was used for the first time to light a London street. In January, 1807, one side of Pall Mall, between St. James's Palace and Cockspur Street, was ablaze with gas-lamps, much to the wonder and admiration of the passers-by.

In 1809, Winsor applied to Parliament for a charter permitting him to form the National Heat and Light Company. Murdock opposed this application, declaring that he himself was the first to make and use gas for lighting. Winsor's charter was refused, but, on a second application in the following year, he was allowed to form the Chartered Gas Light and Coke Company, the forerunner of the present London Gas Light and Coke Company.

Westminster was the first district of London to make use of gas for general street lighting. Westminster Bridge was lighted in 1813, and the streets of Westminster the following year. Three years later, gas was in common use in most parts of London, though some people took objection to it. The gentlefolk of Grosvenor Square, for instance, refused to have anything to do with it, and that select neighbourhood was not lighted by gas until 1842.

Many of the clergy were against gas-lighting, declaring

it to be "profane and contrary to God's law." It was not until after the beginning of Queen Victoria's reign that it was used in churches to any great extent.

(*c*) The Invention of Matches.

When London streets were first lighted by gas, the lamplighter went round armed with a tinder-box. This was a metal box, containing a piece of flint, a piece of steel, and some bits of linen or cotton, called "tinder." A spark was made by striking the steel and flint together. This spark fell on the tinder and set it aglow; then a "spunk," a slip of wood tipped with sulphur, was dipped into the glowing tinder, and at once burst into flame.

In 1827, John Walker, a chemist of Stockton-on-Tees, made a match that could be lighted by rubbing. These matches, slips of wood dipped in a mixture of sulphur and chemicals, cost a shilling a box. They were lighted by drawing through folds of glass-paper, i.e. paper coated with finely powdered glass, a sheet being supplied with each box. A few years later matches were being made in London, but old-fashioned people were afraid of "matches that lighted themselves," so it was not until ten years had passed that they were in general use.

There is a Cornish story about an old woman and her first box of matches. An old Cornishwoman had run out of tinder, so she went to a neighbour to beg some. The neighbour said she had something better than tinder, and offered her a few matches. Having been shown how to use the new light-maker, the old lady returned to her cottage. Before going to bed, however, she wanted to make quite sure that the matches would light. She struck each one in turn, and, finding it all right, blew it out. The next morning she was again at her neighbour's door, asking for tinder, because the

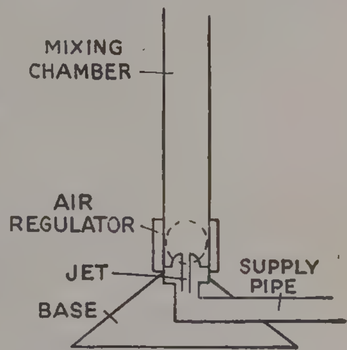
matches would not light, although they had been all right the night before.

(*d*) Hot Gas and Bright Gas.

Bunsen's Burner and Welsbach's Mantle.

During the early part of the nineteenth century, men discovered many things about gas. They found ways of making coal-gas purer and richer; and it became healthier, safer, and easier to use.

Some men tried to make the flame brighter. They learned that the brightness of the flame was due to the little particles of carbon in the flame itself. If the flame could be made hotter, the particles became incandescent, that is, they glowed with a white heat. In 1826, it was discovered that pure oxygen and hydrogen gases without any carbon, when burned, gave great heat but no light whatever. When carbon, in the form of a cylinder of compressed lime, was placed in the flame, a very brilliant light was produced. It is called limelight, and has been used in theatres and places where a very bright light is required.



Section through a Bunsen Burner.

Other scientists turned their attention to making the gas flame hotter. In 1853, a German chemist, Robert Wilhelm Bunsen, discovered that if air was allowed to mix with coal gas, the flame was much hotter, but there was no light. He made a gas-burner in which the gas was sent through a tube that had a hole at the base as well as at the top. In this way air was drawn in, and the gas burned with a dim blue smokeless flame.

With the invention of the Bunsen burner, gas came

into use for heating as well as lighting. The gas-ring appeared, and also the early form of gas-fire in which a Bunsen burner heated lumps of asbestos, a mineral fibre that can stand great heat without burning. Both gas-fires and gas-stoves are now in general use, on account of their economy and cleanliness.

Towards the end of the nineteenth century, electric light began to rival gas for lighting purposes, and it was necessary to find a way of improving the brightness of the gas flame, if it were to remain popular. Many men tried without success to find a substance that would produce a white light.

Auer von Welsbach, an Austrian, was making experiments with some rare earth, and, in order to get a better result, he dipped some cotton threads in a solution of metallic salts. After burning these on platinum wire, he found a copy of the threads, made of the metal oxide, was left, and that it glowed brightly in the flame.

This gave him the idea for the incandescent mantle. He made a mantle of cotton thread, soaked it in the solution, and, when it was dry, put it over a Bunsen burner. The cotton at once burned away, but the mantle of earth oxide was left, and, with this, the light obtained was greatly in excess of that given by an ordinary burner, though of a slightly greenish tinge.

Welsbach patented his incandescent mantle in 1886, but it was not a success. Purchasers of the mantle were delighted with the brightness of the light, but were very disgusted when the mantle crumbled away after a few days' use. The invention was declared to be far too expensive.

But Welsbach did not despair. He tried again and again, using many kinds of rare earths, until, in 1890, he made a really strong mantle by using a mixture of

two kinds—ninety-nine parts of one kind, and one part of the other. These mantles lasted well, gave a better light, and used less gas; and they are still popular rivals of electric light.

QUESTIONS.

1. How did Murdock experiment to improve gas lighting?

2. When was the first Gas Company formed, and who obtained the charter?

3. What was the value of the work of Bunsen and Welsbach in connection with gas lighting?

4. What is the source of the gas supply in your town to-day? How is it obtained, stored, and brought to your home?

15. THE STORY OF THE SEWING MACHINE.

(1755–1930).

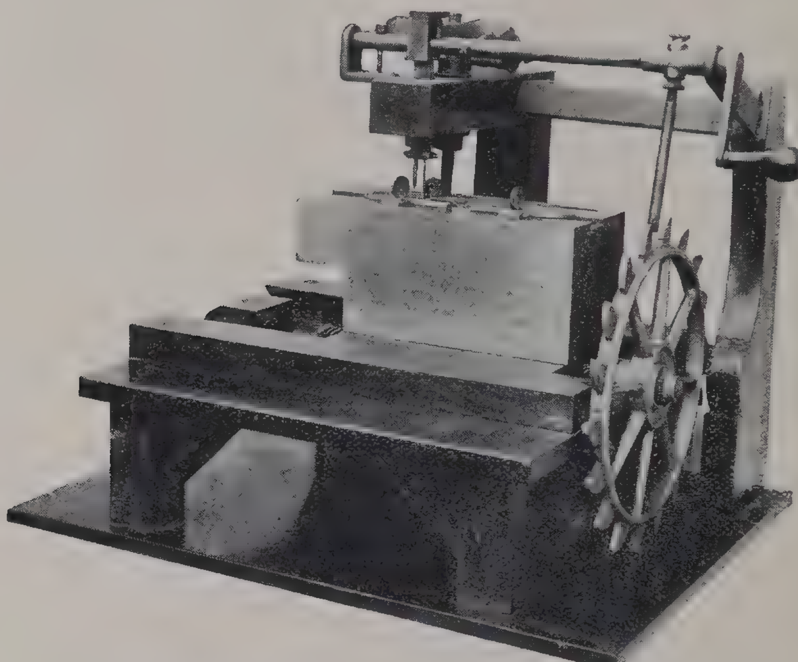
(*a*) Trying to Sew by Machine.

Every girl and, I expect, every boy knows that the sewing machine is one of the most useful things in the home. This clever aid to needlework is the outcome of many inventions and improvements, and many inventors were working at the idea almost at the same time, but each unknown to the others. Most of these men got no reward for their work, because, for various reasons, they were unable to complete the invention, and also because the public showed little interest in the idea when it was first suggested.

It was clear, no doubt, to many, that a machine that would do away with the slow, tiresome method of sewing by hand would be a useful thing, but it was a long time before any plan for such a machine was thought out. Those who first worked at the idea, failed because they tried to make the movements of the machine imitate

the movements of the needlewoman, and this plan did not work.

The first inventor to try methods for easier sewing was one Charles F. Weisenthal, who, in 1755, made a double-pointed needle with an eye in the middle, the



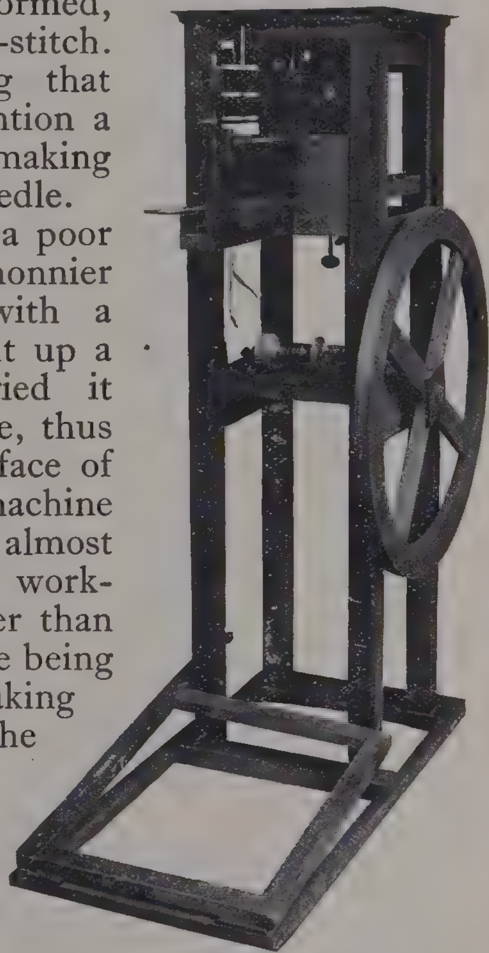
Saint's sewing machine, 1790. Model constructed from the original designs for the Paris Exhibition, 1878.
Courtesy of Science Museum.

idea being that it would save inverting the needle in embroidery.

In 1790, Thomas Saint took out a patent in England for a machine for stitching, quilting, or sewing. This machine was really intended for leatherwork, and it was fitted with an awl such as shoemakers use. This awl pierced a hole in the material; then a spindle and projection laid the thread over the hole, and a forked needle pressed a loop of thread through it. The loop was

caught on the under side, and the work moved on one stitch. The next stitch was made in the same way, but it was within the first stitch, which was thrown off the hook as the next stitch was formed, thus making a kind of chain-stitch. Saint missed the one thing that would have made his invention a success—he did not think of making an eye in the point of his needle.

Forty years later (1830), a poor French tailor named Thimonnier made a machine fitted with a hooked needle which brought up a loop of thread and carried it through a loop already made, thus forming a chain on the surface of the material. Thimonnier's machine was clumsy, being made almost entirely of wood, but it was workable; and, in 1841, no fewer than eighty of these machines were being used in a Paris factory for making army clothing. Then, as in the case of the spinning and weaving machines, the invention aroused jealous anger. The mob determined to destroy this new "enemy," and wrecked the factory, destroyed the sewing machines, and nearly murdered the inventor.



A replica of Thimonnier's sewing machine, 1830.
Courtesy of Science Museum.

Thimonnier, however, did not easily lose heart. He went on with his work, improved his invention, and made a machine entirely of metal. He also took out

patents in Great Britain. Then, in 1848, came "the Year of Revolutions"; France was in a turmoil, and no one had any thought to spare for sewing machines. Thimonnier sold his British patents; one of his machines was shown in London at the Great Exhibition of 1851, but it seems to have attracted very little notice, and the inventor died a few years later without reaping any reward from his work.

While Thimonnier was working at the sewing machine in France, an American, Walter Hunt, was engaged in a similar task in New York. He was the first inventor to think of the pierced point for the needle, and of the use of a double thread which made a stronger stitch called lock-stitch.

Hunt sold his machine to a blacksmith named Arrowsmith, but, strange to say, neither Hunt nor Arrowsmith applied for a patent, or took any steps to advertise the machine, until other inventors began to make sewing machines. Then they found it was too late, so Hunt lost the honour that should have been his.

(*b*) Elias Howe (1819–1867).

The man to bring the invention to a successful completion was Elias Howe, a native of Spencer, Massachusetts.

Howe was employed in the works of a cotton-machine maker. His wages were very small, hardly enough to keep his family fed and clothed, yet, after a long hard day's toil, he would come home, and work all the evening in a dismal garret, making model machines. He knew nothing of the attempts of other inventors, but depended on his own ideas and a general knowledge of machinery to help him. He felt sure that a sewing machine was one of the things badly needed in the world, and he

hoped, if successful, to make a fortune by his invention. So he struggled on year after year, often cold and hungry, but thinking of his models all day, and dreaming of them at night.

Like other inventors, he tried to work the machine by the same method as sewing by hand, having the eye at the heel of the needle, but it was impossible. Night after night he toiled for three years, but without success.

One night, tired out and thoroughly disappointed, he went to bed—to dream of sewing machines. He dreamt that he was making a machine for a savage king, who gave him twenty-four hours to finish it and make it work. If he failed, he was to die. In his dream he did fail, and was led out to execution by warriors carrying spears. The spears were *pierced through the heads*.

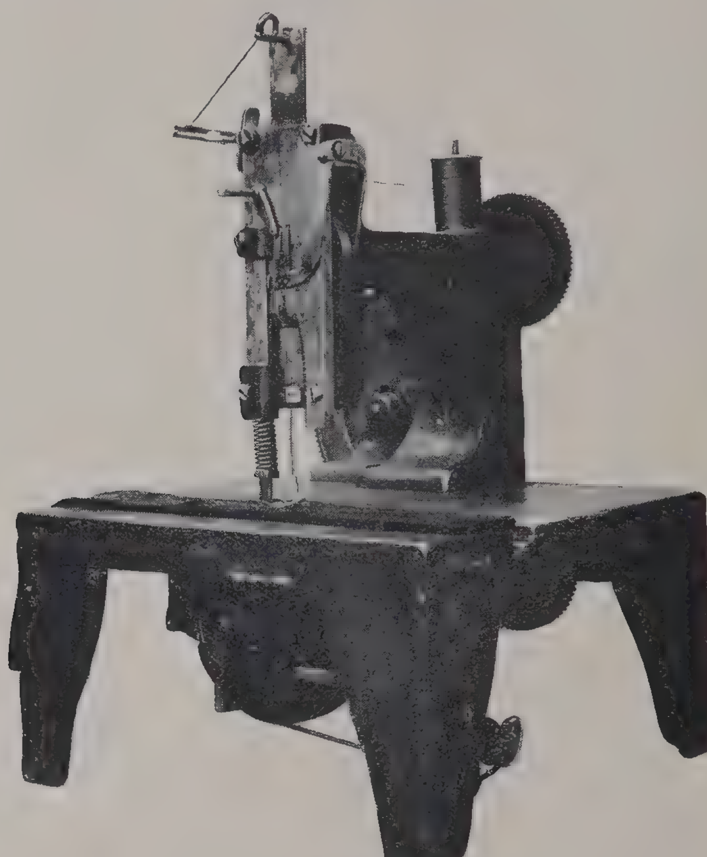
Howe awoke with a start. He had a new idea for his machine needle—to pierce it through the point. He sprang out of bed, rushed to the garret, pierced a needle through the point, and ran a piece of thread through. It sewed! He had found the secret at last!

But, when he had found out the secret, Howe was too poor to make much use of it. He managed to take out a patent (1846), but failed to interest manufacturers in his machine. He sold the English rights to a corset maker, named Thomas, who took out a patent in his own name, and persuaded Howe to come to England to make certain alterations that would make the machine more useful for his special form of work. Howe came to England, but was bitterly disappointed to find that Thomas would pay him only a weekly wage for improving his own machine.

Then news reached Howe that his wife was dying of consumption, brought on by poverty and hardship, while manufacturers were copying his machine, and making

fortunes out of it. He borrowed money to pay his passage by steerage to America, and pawned his American rights in England.

His wife died, but Howe fought hard for his rights



The original Singer sewing machine.
Courtesy of Science Museum.

with the men who were making machines on his model. The most successful of the sewing machine manufacturers was Isaac Merritt Singer, who had taken out a patent in 1851. It was ten years from the time of completing his invention before Howe won any success. Then the tide of his fortune turned at last. He won the victory over

the rival machine makers, and, with thirteen years of his patent to run, he was to be paid a sum of money for every machine not of his own manufacture. In the thirteen years before his patent expired, Howe received, in this way, from £35,000 to £40,000 a year.

Howe's first sewing machine is still in existence. It is a crazy, clumsy-looking affair, but still a wonderful machine. Singer's original machine is a much neater-looking article, but it is easier to improve on an idea that has been worked out, than to put it in shape first of all.

Many inventors have since added to the usefulness of the sewing machine. Its general working has been improved, and it has been adapted to special uses. Some machines are capable of doing all kinds of embroidery and ornamental stitching; others will sew button-holes at the rate of eight or ten a minute; while others again will sew on buttons, making the required number of stitches, stopping with the needle at the highest point, and cutting the thread off close to the underside of the work. Some machines have two or more needles fitted for making parallel rows of stitching. Other forms of machines are made for the use of glove-makers, umbrella-makers, and shoe-makers.

Electricity has now been brought into use to work sewing machines, and this has proved especially useful in working on hard materials such as carpets.

QUESTION.—Outline the story of the sewing machine.

16. THE WORLD'S MESSENGERS—THE ELECTRIC TELEGRAPH AND TELEPHONE.

If you live in a big town, you will often see the telegraph messenger on his bicycle, hurrying along with a message. You are also familiar with the bright orange-

coloured envelope in which the message is delivered. Whether you live in town or country, you will have seen the tall poles bearing the wires along which the messages are flashed from town to town.

Now let us read the wonderful story of the telegraph and telephone—the world's messengers, carrying messages not only from town to town, but from country to country, and continent to continent, all round the globe.

You have already heard that when men had been experimenting with electricity for some time, they found that the electric current could be carried to a distance along a wire, if that wire was insulated, that is, fitted with something that would prevent the electricity escaping. (The white earthenware or glass cups which you see on the telegraph poles are the insulators.)

Presently men began to wonder if they could put this discovery to any use, and, in 1753, a gentleman wrote a letter to the *Scots Magazine*, suggesting that messages might be sent along insulated wires. His idea was to have twenty-six wires, one for each letter of the alphabet. By charging the wires required, one after another, the message could be spelled out. At the other end, it could be read by watching the movement of small pieces of paper marked with the letters and placed under the ends of the wires.

Another plan suggested by the same writer was that of fastening a small light pith ball to the end of each wire. The electric current passing into the ball would make it move towards a bell and strike it.

Other ideas, similar to these, were thought of from time to time, but many years passed before any real use was made of them.

In 1814, a Danish scientist named Hans Christian Oersted found that a wire joining two metals in an electric

battery such as Volta had recently made, would move the needle of a compass to one side. If he reversed the wire over the needle, the needle moved to the other side. By using a long wire, the needle could be moved even from a distance.

This discovery suggested a far better way of sending signals by electricity. It was quite easy to say that moving the needle once to the right meant one letter, once to the left meant another; that one right and one left meant a third letter, and two rights a fourth, and so on. Other discoveries were made about the electric current, and these were brought into use in sending signals by electricity, or, as we say, by telegraph (a word formed from Greek *tēle*, afar, and *graphein*, to write).

(*a*) The Morse Code.

SAMUEL F. B. MORSE (1791–1872).

The inventor of the first code or system of dots and dashes used in telegraphy and in signalling was an American, Samuel Morse.

Mr. Morse was an artist. In 1829, he visited Europe for the purpose of studying the work of the great artists of the sixteenth century. On his return voyage, in 1832, he first became interested in electricity.

Steam had not yet been brought into general use for ocean-going ships, and the voyage was a long one. On the *Sully*, the ship in which Morse sailed from Havre to New York, was a Dr. Jackson, who was interested in electricity. During the voyage he described to Morse some of the experiments he had seen performed in Paris.

Many discoveries were being made at that time by Faraday and others. Among them was the electro-magnet, which was a piece of soft iron, temporarily magnetized by the current of an electric coil surrounding it.

Dr. Jackson had a small electro-magnet with him, and showed it to Morse, who was eager to hear all about it. He asked the doctor if it took a very long time for electricity to flow through so long a wire as that of the magnetic coil. Jackson replied that in the experiments he had seen the current passed almost instantly along any wire, no matter how long. " If that is so," exclaimed Morse, " I see no reason why signals may not be sent by electricity."

The more he thought of the idea, the more certain did Morse become that it might be carried out, and he spent the rest of the voyage in planning an electric telegraph. He drew many diagrams in his sketch-book to show how he thought a telegraph might be made, and by the end of the voyage he had his idea fairly worked out. He was determined to try it.

As he left the vessel at New York, he said to the captain, " Well, captain, should you hear of the telegraph one of these days as the wonder of the world, remember the discovery was made on the good ship *Sully*."

To the surprise of his friends, Morse was now more interested in his new idea than he was in his pictures. But he still had to paint for his living, and could work on his invention only in his spare hours. His brothers offered him a room in a business house in New York to serve as a workshop, but for a long time the one room served as studio, kitchen, and bedroom as well.

Morse had very little money to spare for apparatus, and even if he had had the money, electrical odds and ends that we can buy so easily to-day were not to be had at that time. Even electro-magnets were not for sale. He had to think of ways to contrive and make apparatus for himself.

For a magnet he had to get a small rod of iron from a

blacksmith, and tell him how to bend it into a horseshoe shape. Then he had to wind the horseshoe with insulated copper wire. But insulated copper wire was not easy to get; even ordinary copper wire was very scarce and very dear. Morse bought a few yards, however, and wound it round and round by hand with cotton thread for insulation. In this way he struggled on, making his own models, moulds, and castings, and practising severe self-denial to find money for materials.

It was not until 1837, five years after his voyage in the *Sully*, that Morse was able to invite some of his friends to his studio to see the first telegraph instrument. Among his visitors was Alfred Vail, a member of a firm of iron and brass workers in New Jersey; and he was so pleased with the idea that he offered money and materials for further tests.

With Vail's help Morse applied for a patent in America, and set out for Europe to take out patents there. But the trip was not a success. In England the patent was refused, and also in Russia. In France he was granted a patent, but the French government afterwards took this over without paying Morse anything for it. After a year's absence he returned to America.

By this time, Morse had done all he could do without help from his government. In 1843, he applied for a Bill granting him funds to put up a test line from Washington to Baltimore. He knew that many members of the Congress were against the Bill, and he quite expected it to be defeated; in fact, he had bought his ticket to return to New York the next day—with 37 cents (equivalent to about 1*s.* 6*d.*) in his pocket.

But the Bill was passed, so he remained in Washington. His friend Vail was again of great help, and the work was begun. At first the wires were laid underground;

but this was too expensive, so he decided to mount them on poles with glass insulators to prevent the electricity passing down the poles into the ground.

The line was opened for public use in April, 1845. Messages were sent by the " click click " method, and the charge was one cent for every four letters. So little interest was taken in the new idea that, in the first four days, only one cent was taken. The only customer was a man who wanted to see the telegraph working, free of charge.

He was told that this was against the rules. He then asked for one cent's worth of telegraphy. At that time there was a code or list of numbers used for some messages. In the code " 4 " stood for " What is the time ? " This code message was sent to Baltimore, and the answer " 1 " received, meaning " 1 o'clock." This was really only *half* a cent's worth of telegraphy, but the man paid his cent and went away satisfied.

(*b*) Charles Wheatstone (1802–1875).

Meanwhile experiments were going on in England and Germany. A German named Karl August Steinheil had made a telegraph which recorded messages by making ink dots on a paper ribbon.

Sir Francis Ronalds, the son of a London merchant, had also carried out a number of successful experiments at his house near London. He offered his invention to the government, but it was refused because telegraphs were considered to be " quite unnecessary."

In 1836, an officer in the Madras army, William Fothergill Cooke, was home on leave. He visited several of the universities of Europe, and became interested in the idea of sending signals and messages by means of electricity.

On his arrival in London he met a clever man, Professor Wheatstone, a lecturer at King's College. They talked over the idea and began to work it out. Wheatstone had in his youth been put to learn the trade of a musical instrument maker, and the things he learnt then helped him very much in the building of a telegraph instrument. In 1837, they applied for a patent.

In July of that year the first public trial was made. One of the inventors was stationed at Camden Town, and the other at Euston. The result was quite satisfactory. Among those present at the test was George Stephenson.

Reduced facsimile of one of the first advertisements of the electric telegraph.
Courtesy of Science Museum.

Soon after this, the first actual telegraph was set up on the London and North Western Railway, and the first public line from Paddington to Slough was opened in 1843. At first the telegraph was almost entirely in the hands of the railways, but in 1846 the Electric Telegraph Company was formed. The telegraphs were taken over by the government in 1868.

The Morse Code is still used in the United States and Canada, and a modified form of the Code, differing only slightly from the original, is used as the International Code.

(*c*) Telegraph Cables under the Ocean.

William Thomson, Lord Kelvin (1824–1907).

William Thomson, the man to whom we owe the submarine telegraph, was born in 1824 at Belfast. His father, who was a professor of mathematics, took up an appointment at Glasgow, when William was ten years old.

A	•—	J	•———	S	•••	2	••—••
B	—•••	K	—•—	T	—	3	•••——
C	—•—•	L	•—••	U	••—	4	••••—
D	—••	M	——	V	•••—	5	•••••
E	•	N	—•	W	•——	6	—••••
F	••—•	O	———	X	—••—	7	——•••
G	——•	P	•——•	Y	—•——	8	———••
H	••••	Q	——•—	Z	——••	9	————•
I	••	R	•—•	I	•————	O	—————

The International Morse Code. It is slightly modified from the code which Morse invented.

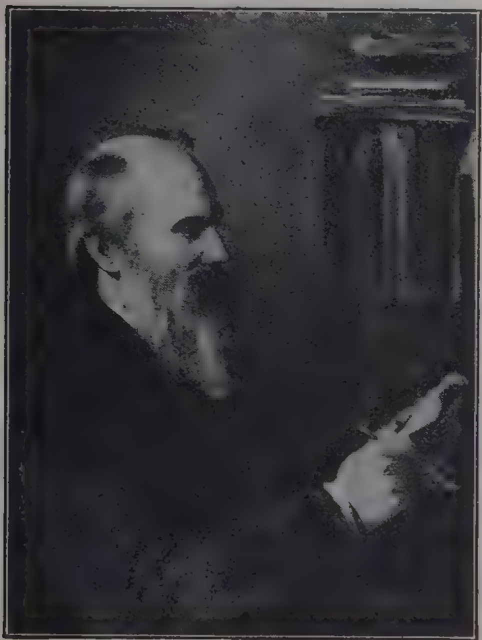
Thomson was educated at Cambridge, and then went to Paris to study science, as there was then little opportunity for the student of experimental science at his own university. In 1846, when only twenty-two years of age, he returned to Glasgow as professor of natural philosophy, a position he filled for fifty-three years.

His great work from 1854 onward was in connection with submarine telegraphy. As early as 1845, there had been talk of laying a telegraph cable under the waters of the Atlantic, by which messages could pass between England and America, but the great task was not attempted until eleven years later.

In 1851, a cable was laid from the South Foreland

across the Straits of Dover to Sangatte, in France, and two years later, after many failures, another was laid from Port Patrick, in Scotland, to Donaghadee, in Ireland.

When Professor Thomson began the study of ocean telegraphy, he was often told that the difficulties involved were so great that it could never be possible to send signals or messages under the sea. But he set to work to overcome the difficulties, and to plan instruments that would do the work. At last all was ready for the laying of a cable under the Atlantic from Ireland to America.



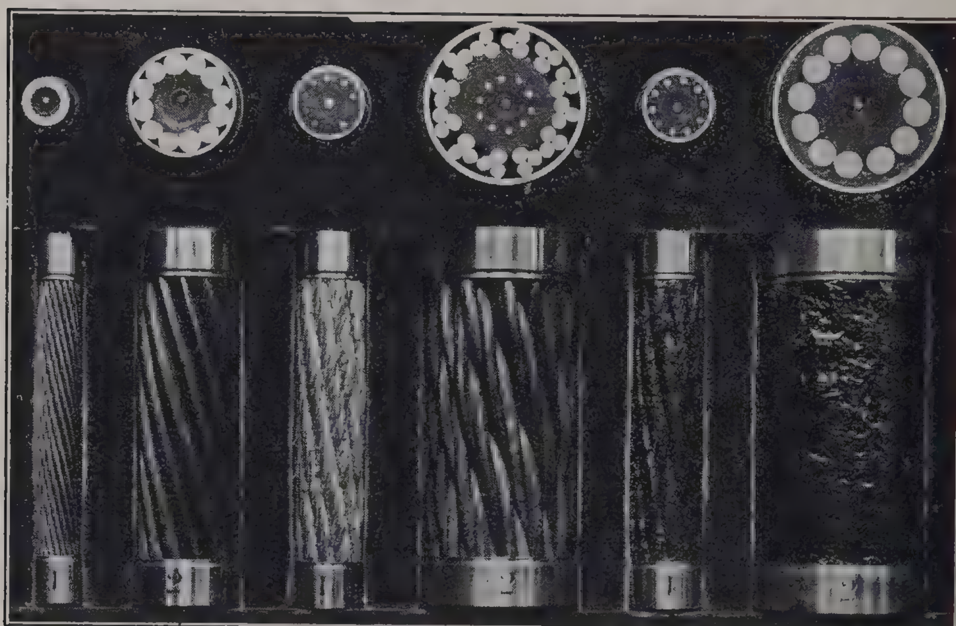
Lord Kelvin.
National Portrait Gallery.

In July, 1856, the immense coils of cable were prepared. Half of the cable was stowed in the American ship, *Niagara*, and half in the British ship, *Agamemnon*. The shore end was landed at Valentia Harbour, and the *Niagara* began to pay out her half of the cable. After paying out 380 miles in six days, the cable broke, and the two ships came back to Plymouth.

The next year a second attempt was made. This time the ships were to meet in mid-ocean, join their cables, and steam away from each other in opposite directions. Storms hindered the work; the cable broke three times; then the ships missed each other. At last, on August 5th, 1857, the *Niagara* landed her end at Trinity Bay, New-

foundland, and on the same day the *Agamemnon* landed hers at Valentia.

The operator, however, mistook Professor Thomson's directions, and used too much power, with the result that



Atlantic Cable, 1857. 2,174 nautical miles. Atlantic Cable, 1865. 2,300 nautical miles. Atlantic Cable, 1866. 1,852 nautical miles.

In each case, No. 1 shows the main cable, and No. 2 the shore ends, and the cross-sections are given above. Scale 1 : 4.

Courtesy of Science Museum.

after a few months the cable ceased to transmit messages.

It was not until 1865 that an attempt was made to lay a new cable. This time a single ship, the *Great Eastern*, was employed; but again the cable broke. The following year the *Great Eastern* set out once more. She left Valentia on July 13th, paying out the cable, and without mishap reached Trinity Bay a fortnight later. Then she returned, managed to pick up the cable lost the year before, and finished laying that one also.

So the first Atlantic cables were laid, and Professor Thomson, who had done so much to bring about success, was knighted. In 1892, he became a peer with the title of Baron Kelvin.

The *Great Eastern*, which was used in laying the Atlantic telegraph cable. This steamer was propelled by both screws and paddles. Length, 695 ft.; width, 83 ft.; width over paddle-boxes, 120 ft.

From a print in the Science Museum.

(*d*) The Story of the Telephone.

ALEXANDER GRAHAM BELL (1847–1922).

The telephone (Greek *tēle*, afar; *phōnē*, sound, voice) is another of the world's wonderful messengers. It does more than carry a message by "click click" signals; for when we listen at the telephone, we actually hear and recognize the voice of a friend speaking to us from a long distance.

Wheatstone, one of the inventors of the telegraph, had made experiments with a "magic lyre," showing that when the sound boards of two musical instruments are connected by a rod of pine wood, a tune played on one

is reproduced on the other. But the first man to make real use of the idea was Alexander Graham Bell, a Scotsman living in America.

Bell was a teacher of deaf children, and this work made it necessary for him to study sound, and also the way in which sound acts on the ear-drums. When Bell heard that men were trying to make a musical telephone, and to send actual sounds over wires, he made up his mind to try what he could do in that way.

At this time he was teaching the son of a rich man, and went to live at his house in Salem, Massachusetts. In the cellar of this house he had a little workshop, where he spent his spare time making experiments with tuning forks and electric batteries. He wanted to make an instrument that would do more than "click" the message; he wanted something that would carry the sound of the voice.

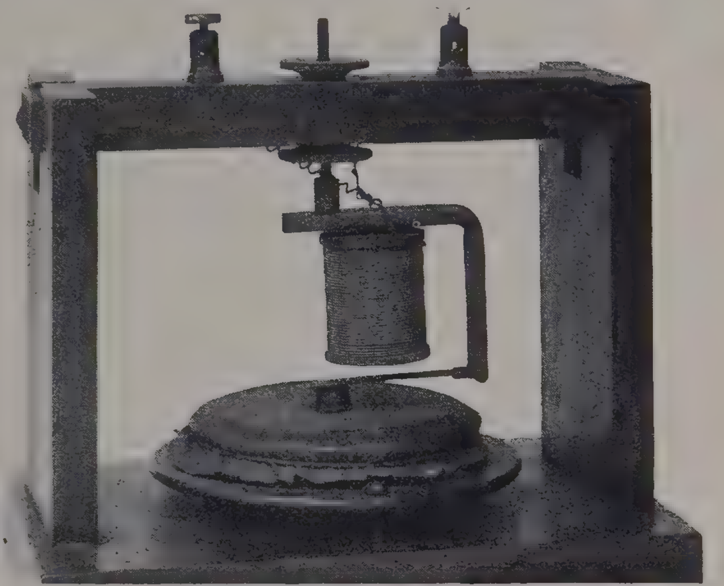
When Bell was twenty-eight years of age, he went from Boston, where he was teaching in a deaf school, to Washington for a holiday. At Washington he met a man of science named Joseph Henry, who was making experiments in electricity. When Henry heard of Bell's idea, he advised the young man to study electricity, as it would help him. "You have the idea for a great invention," he said. Bell was encouraged by this, and, on his return to Boston, followed the Professor's advice.

He had a friend, Thomas Watson, who helped him to make discs and set up wires. At last they made an instrument that would carry sounds, but it did not talk—these sounds did not form words.

Another year of hard work passed. Then, one day, Watson was in the basement at the end of the wire, when he heard Bell say clearly, "Watson, come here; I want you."

Watson ran up three flights of stairs, crying excitedly, "I can hear you; I can hear *the words*."

A little later Bell's telephone was shown at an exhibition in Philadelphia. Among the visitors to the exhibition was the Emperor of Brazil, who knew Bell, having visited his school in Boston. The judges were inclined to pass over the telephone as a mere toy, but the Emperor said he should like to listen to it. He put the receiver to his ear, and Bell's assistant spoke from the other end. "It talks!" cried the Emperor delightedly. "It talks!" he repeated.



An early Bell telephone (about 1875). The instrument was connected to a battery by one of the screws at the top, and by the other, to a similar instrument placed at a distance.
Courtesy of Science Museum.

Another visitor to the exhibition was Sir William Thomson (afterwards Lord Kelvin); he declared the telephone was the most wonderful thing he had seen in America.

Bell applied for a patent in February, 1876, and on the same day a similar application was made by another experimenter and electrician, Elisha Gray, of Boston (Mass.). But it was proved beyond doubt that the honour of inventing the telephone belonged to Bell. In the same year Bell was granted a patent for Great Britain.

The next year, Thomas Alva Edison, another American inventor, took out patents for improvements in telephones.

At the time of Bell's invention, the telephone was looked upon as a toy, but it has become one of the most useful helps, both to business men and to others. The time saved by a telephone call is very important, not only for business people, but for others. In case of accidents or fire, the telephone brings speedy help; the police, in particular, find the telephone of great value, when in pursuit of criminals.

Many improvements have been made of late years. Since the invention of wireless telephony, of which we shall speak in another chapter, it is possible to speak over the telephone to a listener thousands of miles away. On April 30th, 1930, the Prime Minister, Mr. Ramsay Macdonald, had a chat with Mr. Scullin, the Prime Minister of Australia, over 12,000 miles of sea and land, or half-way round the globe, and communication has since been established between many other places that are thousands of miles apart.

Questions.

1. Say how the idea of sending messages by electricity originated.
2. What was Oersted's great discovery?
3. What is an electro-magnet? What use did Samuel Morse make of one? What difficulties did he meet with?
4. Describe the opening of the first telegraph line in America. Give the date.
5. Who were the pioneers of telegraphy in England? When was the first public line opened, and where?
6. Describe the difficulties Lord Kelvin had to overcome in laying a submarine cable between America and England.
7. How did the first ideas of telephony come to Alexander Bell?
8. Where did Bell exhibit his first telephone, and when did he obtain his patent for America and Great Britain?

17. FLORENCE NIGHTINGALE AND THE ART OF NURSING.

(1820–1910).

At the beginning of the nineteenth century there were no properly trained, skilful nurses to be had. The kind of woman who "went out nursing," is described in one of Dickens's novels, *Martin Chuzzlewit ;* for he tells us in the preface that Betsy Prig and Sarah Gamp were portraits drawn from life, and that the original of Betsy Prig nursed one of his friends through an illness. Betsy would even steal her patient's pillow in order to make herself comfortable in an armchair.

Nursing as a real profession, for which educated women were properly trained, owed its beginning to Miss Florence Nightingale, whose work in the Crimean War (1854–6) completely changed the service of sick nursing.

Florence Nightingale was born in the city of Florence in Italy, and was named after her birthplace, but her childhood was spent in England, chiefly in Derbyshire. When quite a tiny girl, she loved to play at nursing, and practised bandaging on her dolls. Her first living patient was a shepherd's dog that had broken its leg.

When Florence grew up, her parents, who were well-to-do and of good social standing, wished her to go to London to be presented at Court. She went, but her first season in town was spent, not in going to balls and parties, but in visiting hospitals, reformatory schools, and other institutions. She found there was no proper training school for nurses in England, and as she had a great wish to learn as much as she could of the art of sick-nursing, she went to Germany, where it was possible to obtain the desired instruction.

Germany has the honour of beginning a new order

of things in training women as sick-nurses. In 1836 an institute for training deaconesses had been opened at Kaiserswerth, in the Rhine Province, and there Florence Nightingale spent six busy months, learning every detail of a nurse's work with great thoroughness. From Kaiserswerth she went to Paris, where she studied the methods of nursing and hospital management under the direction of the nursing sisters of the Order of St. Vincent de Paul. On her return home, she put her newly acquired knowledge to practical use by re-organizing a Nursing Home for Governesses in Harley Street, London.

But before long Miss Nightingale was called to a far greater task. In 1854 the *Times* newspaper published a letter from its famous war-correspondent, William Howard Russell, who had been sent to the Crimea to report on the progress of the war which was being waged in that Peninsula by the British and French in alliance against the Russians. In this letter, Mr. Russell told of the sad plight of the British soldiers lying in the hospital at Scutari, a city on the Bosphorus opposite Constantinople. The poor men were left to the care of old pensioners who were of little use. Sometimes the wounded men were left a whole week before their wounds were dressed; and they lay in terrible pain, their clothes stiff with the mud and blood of the battle-field. In addition to all this, there was a shameful lack of medical stores and nourishing food.

Mr. Russell went on to say that the French army had fifty Sisters of Charity who attended to the French wounded, and he asked whether there were no brave and kind-hearted women in England willing and able to serve their country by going to nurse the British soldiers.

When Florence Nightingale read this sad story, she longed to go to Scutari and help the poor soldiers. At

first she wondered if she would be strong enough for the hard work of a war hospital, but she felt she ought to offer her services. She wrote to the Minister for War, telling him that she would be willing to go to Scutari, and it happened that at the same time the Minister, who knew of Miss Nightingale's interest in hospital work, was writing to her, asking her to go out and take charge of the war hospitals.

Florence Nightingale.
National Portrait Gallery.

In ten days everything was settled, and Florence Nightingale, with a band of thirty-seven assistants, was on her way to Scutari. The first part of their journey was through France. They crossed the Channel to Boulogne, where their arrival caused great excitement. Sturdy fisherwomen, whose husbands and sons were fighting side by side with the British in the Crimea, seized their luggage and dragged it to their hotel, refusing to accept any pay. The landlord of the hotel told them to order what they wished, adding that he was only too glad to be allowed to entertain them. When they left Boulogne to continue their journey, a crowd of well-wishers gave them a great " send-off."

When the party reached Constantinople, which is separated from Scutari by a narrow strait, the Bosphorus, they heard of the great Battle of Balaclava, and of the terrible losses to the British cavalry in the now famous

charge of the Light Brigade. " Four hundred wounded are arriving at this moment for us to nurse," was the first news Miss Nightingale was able to send to her parents from the seat of war.

The nurses reached the hospital at Scutari, and

Florence Nightingale in the Hospital at Scutari.

Rischgitz.

although the outside of the building was rather fine, inside, everything was most miserable and dirty. The first thing Miss Nightingale did on entering one of the wards was to drive a large rat from under one of the beds with her umbrella. She found the beds very uncomfortable, with sheets of coarsest canvas ; old wine-bottles served as candlesticks ; there were no mops, no plates, no knives, no forks, no basins—in fact there were none of the most necessary things required in nursing sick people.

It was very hard work. Not only was there nursing to be done, but stores had to be ordered, even clothing for the men: a laundry had to be set up, in which five hundred shirts were washed every week, besides countless other articles. Miss Nightingale and her nurses were never idle. They had bandages to make, lint to prepare, mattresses and pillows to sew.

But, when Christmas Day came, two months later, the hospital was a different place. The sick men lay between comfortable sheets, they had plenty of proper food, and they drank the health of Queen Victoria, who had sent them a Christmas greeting.

In the New Year fresh nurses arrived, and they were needed. The long, tiresome siege of the Russian port of Sebastopol had begun, and men were brought in, suffering, not from wounds, but from the hardships of the frozen trenches and from cholera.

For nearly two years, Miss Nightingale toiled on. Even when she was ill with fever herself, she refused to leave her post, and was back at work as soon as she was strong enough. She stayed on at Scutari until the war was over, even until the last patient had left the hospital.

In spite of her courage and endurance as a nurse, Florence Nightingale was a very shy woman. She was so afraid of attracting attention that she travelled home under the name of Miss Smith, and would not let her own family know the exact time of her arrival. Early one morning she walked up from the little country station near her home, and, it is said, entered the house by the back door.

The people of England wanted to make Miss Nightingale a present worthy of the great work she had done, but she refused to take anything for herself. There was a way, however, in which the nation could show how much

they valued the brave woman's work, and that was by making it possible to extend the work she loved so well. The large sum of £50,000 was raised, and with this was founded in London the Nightingale Home for training nurses at St. Thomas's and King's College Hospitals.

The hardships she had endured during her war work very seriously affected Miss Nightingale's health, and although she lived to the age of ninety, she was almost an invalid, and obliged to lead a very quiet life. She did much useful work, however, by writing books and pamphlets on nursing, and she was frequently consulted on matters of hospital management and sick-nursing.

With the help of a County Council Committee, she organized, in 1892, a " health crusade " in Buckinghamshire. Teachers were sent round among the cottagers to give practical advice on ventilation, drainage, disinfectants, and general cleanliness.

Miss Nightingale received the Order of Merit from King Edward VII in 1907. She died in London three years later.

(*a*) Sick Nursing and Health Services.

In the last fifty years great progress has been made in the training of sick-nurses. Hospital work is divided into many sections, and nurses are usually training for three or four years before they are fully qualified. In 1916, a College of Nursing was established with the view of forming a centre for all nursing activities, for improving the nursing service as a whole, and also the conditions under which nurses have to work.

Besides the training of nurses for hospital work and private nursing at the homes of patients, there are institutions for training District Nurses who do most useful work in caring for the sick poor in their own homes.

Other trained nurses are employed by the counties and large towns as health visitors, while a most useful work is being done by nurses engaged in infant and child welfare centres. The education committees employ numbers of nurses for visiting the schools, and following up, as necessary, the cases of children after they have been inspected by the school doctors. There is hardly a village in the country that is not in touch with some scheme for the care of the sick, and the promotion of the welfare of infants and children. Many of the town schools are provided with a "clinic," where simple ailments, such as sore fingers and skin troubles, are attended to. These clinics are most useful in checking the spread of skin diseases, and preventing small injuries becoming serious through neglect.

There is also the St. John's Ambulance Association which provides courses of instruction in treatment of the sick, and the methods of rendering "first-aid" in common accidents. The work of the nurses during the Great World War was a splendid example of voluntary self-sacrifice and hard work in a good cause.

Questions.

1. Describe Florence Nightingale's work (*a*) in the Crimea; (*b*) for the training of nurses.
2. How is National Health cared for to-day?

18. CONQUERORS OF PAIN AND DISEASE.

In this chapter we shall read of some of the people who have tried to conquer disease; but first we must consider the tiny enemies that cause disease.

In the air we breathe, in the soil, and in water there are minute organisms, so very, very small that we can

see them only by using a powerful microscope. They are called microbes (Greek *mikros*, small; *bios*, life). Some of them, being rod-shaped, are called bacteria (Greek *bakterion*, a little staff).

Some bacteria that live in the soil are very useful, helping to get food ready for the plants to take in, and changing dead plants and little dead animals lying in the earth to something that makes the soil richer and helps the plants to grow.

Some bacteria live in the roots of clover, lucerne, and peas. These plants take in a gas called nitrogen from the air, and store it up in little nodules or swellings on the roots. When the farmer ploughs the field, the little root lumps are broken up, and the nitrogen gets into the soil, making it rich and ready to feed the next crop. After the farmers learned to grow lucerne and clover, there was no longer any need to waste land by leaving it lying idle. This is because of the useful bacteria that help to feed the soil.

But there are other microbes that are very harmful. If you cut your finger, and some of these get in, you will find it becomes inflamed and very painful. Other bacteria get into our food, and it is spoiled; milk becomes sour, butter turns rancid, mould appears on the top of jam, pickles, or vinegar, and meat goes bad.

Other microbes or germs are the cause of disease, and carry disease from one person to another. It is only during the last hundred years that men have learned much about these germs. Now scientists can cultivate them, for they are really minute living organisms; and then they try to discover how to destroy them. In this way they find out the best methods of treating the illnesses caused by the germs, and so save life and prevent much suffering.

(*a*) The Conqueror of Smallpox.

Dr Jenner (1749–1823).

In the seventeenth and eighteenth centuries a terrible disease often raged in England and other countries. It was smallpox. Rich as well as poor suffered. Queen Mary, the wife of William III, died of smallpox in 1694. In one year, 1719, no fewer than 3,000 people died of smallpox in London alone; and many of those who recovered from the illness were disfigured by ugly scars.

Then a country doctor, Edward Jenner, found a way to overcome this terrible disease. Jenner was the son of the vicar of Berkeley, in Gloucestershire. As a young man he was apprenticed to a surgeon at Sodbury, in the same county, and later went to London to study under John Hunter, one of the most eminent surgeons of the day. Finally he returned to his native town of Berkeley.

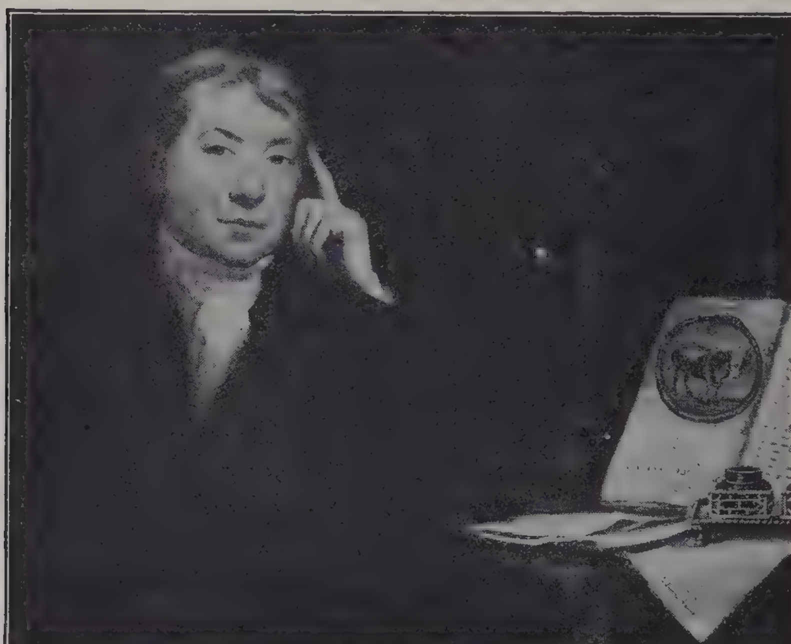
While he was at Sodbury, a young countrywoman came to the surgery. Jenner happened to speak to her of smallpox, and the young woman said that *she* was not afraid of smallpox, because she had had cowpox. Cowpox was a disease rather like smallpox, but not of a serious nature. It was caught by milkers from certain cows.

This idea was quite new to the young doctor, but the woman declared it was true, and could be proved by many people in the neighbourhood. Jenner was interested, and asked other doctors about it, but they said it had not been proved. Some said it was just a foolish notion of ignorant people. Jenner, however, determined to find out more about cowpox. He discovered that people who had had cowpox, were so sure of safety from smallpox that they were willing to go where the disease was raging; and they did *not* take it.

Then Jenner began to wonder if it would be possible

to spread the harmless cowpox among the people, in order to save them from the dangerous smallpox. "For," said he, "if a person can catch cowpox from a cow, why may not one person catch it from another?"

In 1796, he made his first test. He took some fluid



Dr. Jenner.

National Portrait Gallery.

from the hand of a milkmaid suffering from cowpox, and put it under the skin of a healthy little boy aged eight, whose name was James Phipps. Two months later, the doctor inserted smallpox germs, but no smallpox followed.

Dr. Jenner had proved that his idea was right, but for nearly two years he was unable to carry out further tests, owing to the disappearance of cowpox from the dairies. Then he made more tests and published his discovery to the world. His plan for preventing smallpox by means of cowpox is called vaccination.

In six years, news of the discovery had reached the most distant parts of the civilized world. In 1803, the court of Spain sent out an expedition for the purpose of giving vaccination through all parts of the Spanish possessions; for smallpox often raged among the Indians of America, and other native peoples in other parts of the world. This expedition travelled round the world, and returned after three years' absence, having met with great success.

The Empress of Russia ordered the first child vaccinated in Russia to be called "Vaccinov," and to be educated at public expense. In Italy and in Germany festivals were held in Jenner's honour. Even England's greatest enemy, Napoleon Bonaparte, was forced to honour the country doctor. On one occasion Jenner sent a request to Napoleon for the release of an English prisoner; and the Emperor was about to refuse the request, when the name of Jenner was mentioned. "Oh!" exclaimed Napoleon, "we can refuse nothing to *him*."

In England Jenner was honoured by the king and queen; and Parliament voted him two gifts of money, one of £10,000, the other of £20,000. As a result of his discovery, smallpox is no longer one of the most dreaded diseases; in two years (1802–1804) deaths from smallpox fell from two thousand to six hundred. Smallpox is now a comparatively rare disease.

Jenner continued his life as a country doctor. He found time for music and poetry, and for the study of birds and animals, while his kindly, cheerful manner made him a general favourite. He died in 1823.

A plan similar to vaccination is now used in order to prevent other diseases, but in such cases we call it inoculation.

(*b*) The Discoverer of Germs.

Louis Pasteur (1822–95).

In the year before Dr. Jenner died, there was born at Dôle, in eastern France, a boy who was to carry on the work that Jenner had begun. This boy was Louis Pasteur.

Louis Pasteur's father had been one of Napoleon's soldiers, but when the wars were over he became a tanner. It was not a very pleasant trade, working on evil-smelling skins, and Pasteur made up his mind that his little son should have a good education, so that, when he grew up, he should work at something better.

But Louis played in the tanyard, and thought little of the future. When he was old enough, he went to school, but he did not like it. Sometimes he ran away from school to go fishing. The lesson he liked best was drawing, and often, instead of doing his sums, or his reading, he was drawing pictures, quite clever ones too, of his teachers and his classmates.

As he grew older and wiser, Louis began to see how hard his parents worked to get the money for his school fees. Then he was ashamed of his laziness, and began to work really hard. One of his teachers took an interest in him, and said, "You ought to try to go to the University; some day you may be able to teach there."

Louis became interested in chemistry, and worried his teacher with many questions that the poor man could not answer. Then he heard of a druggist who had written some clever articles on chemistry, and begged to be allowed to study with him on Saturdays; the request was granted, with the result that he was soon able to perform experiments that astonished his teachers.

When Louis was sixteen, he went to Paris to study,

but he was so unhappy that he became ill, and his father was sent for to take him home. For a time he went to a school nearer home, but all the while he felt ashamed at being such a coward. At last he begged his father to let him go back to Paris, and his father consented.

So Louis returned to Paris, and there worked at chemistry. He discovered many things up to that time unknown. Some of the experiments that he performed were so wonderful that one of his teachers would not believe in them, until Louis had performed them in his own kitchen; and then, of course, he had to admit that his pupil was right.

Like Dr. Jenner, Pasteur was interested in germs. After he had spent some time at the Paris University, he became an assistant professor of chemistry at Strasburg, then he became professor at Lille, and later returned to Paris, where he began to make discoveries that have saved the lives of thousands of people all over the world.

While making experiments at a brewery where some vats of beer had gone bad, Pasteur proved that it was not due to the gases in the air, but to the tiny *microbes* that floated about in it, clinging to the specks of dust. He began to grow these microbes, and found that they were the cause of sour milk and putrid food. Then he was asked to use his skill in another way.

In the south of France the people made their living by breeding silkworms; and a good deal of space in the cottages was taken up with the racks where the silkworms were fed on mulberry leaves. In 1865, these folks were in trouble; for the silkworms began to die, and the eggs did not hatch, or, if they did, the little worms soon died too. They sent to Italy and Spain for more worms, but in time these, too, sickened and died. There was a danger that there would be no cocoons; then both the

silkworm farmers and the silk spinners would be ruined.

A letter was sent to the French government asking for help. One gentleman, who knew Pasteur very well, said, "Let us send Louis Pasteur to the south. If anyone can find out what is wrong, he will."

Louis said he knew nothing at all about silkworms, in fact he had never seen one; but his friend begged him to go, and to the south of France he went. For four years he worked very hard, keeping and studying thousands of silkworms.

In time, he found out what was wrong. When he looked at the worms under his microscope, he noticed that the sick worms had some very, very tiny specks on their bodies, while the healthy worms had none. He felt sure that the specks caused the disease from which the worms were suffering. Next, he had to find out how the healthy worms caught the disease; and, at length, he discovered this also.

He found that it happened in two ways. If a healthy worm ate a leaf over which a sick one had crawled, it got the disease. Then he noticed that silkworms have little hooks underneath their bodies. When a sick worm crawled over a healthy one, he found that one of the little hooks would prick the skin of the healthy worm, and soon it would be ill. So he separated the healthy worms from the sick ones, and then he destroyed all the sick worms and their eggs.

Just as he had found out how to cure the disease, Pasteur himself fell ill. It was feared that he would die, but after a time he got better, and went back to his work in Paris, although, as a result of this illness, he was always lame.

Pasteur had done more than save silkworms. He had learned that disease is carried from one person to

another by the minute organisms known as germs or microbes. He found that it was possible to handle these germs without taking any harm, if the person doing so had no cuts or scratches on his hands. The germs could not enter the body, unless the skin was broken.

Pasteur at work in his laboratory. From the picture by Edelfelt.
A. G. Photo.

Many wonderful things became known through the careful, patient, and fearless work of this great Frenchman. He helped the farmers by discovering a way to safeguard sheep and cattle from a terrible disease called anthrax. He taught dairy people how to counteract harmful germs in milk. But his bravest and boldest deeds were those that were performed in his search for a cure for hydrophobia, a terrible disease caused by the bite of a rabid animal.

One day a friend who visited Pasteur in his workroom, was much alarmed to find a mad dog tied to the table.

Pasteur was trying to learn about hydrophobia. He made many experiments, and at last felt sure he had found a way to cure the disease. He tried his plan on animals with success. But could he dare to try it on a human being?

Then a little boy named Joseph, who had been bitten by a mad dog on his way to school, was brought to him. At first Pasteur was almost afraid to use the cure which, as he believed, he had discovered. But he knew that the child would surely die if he did not; so he used it. He kept the little boy in his own house, and watched him day and night. Joseph was very happy with his kind friend, who gave him all kinds of pets to play with—tame rabbits, white mice, and guinea pigs. He loved Pasteur very much, but he never guessed how much afraid the great man was. At last Joseph was quite well again, and Louis Pasteur was able to tell the world of another great discovery.

In 1888, the Pasteur Institute was founded in Paris, so that the work begun by the great chemist might be carried on after his death, and other discoveries might be made to help in the fight against disease. To that institute people have travelled from all parts of Europe to be treated for bites of animals. Not long ago an officer, who had been bitten while hunting in Africa, was hurried to Paris for treatment.

Pasteur died in 1895.

(*c*) Two Great British Doctors.

James Simpson (1811–1870).
Joseph Lister (1827–1912).

People who lived at the beginning of the nineteenth century, had a much smaller chance in the fight against disease and pain than we have to-day. It was impossible

for surgeons to do many of the clever things they do now, because they did not know the use of chloroform; and when operations were performed, the patients often died because doctors and nurses had not learned how to keep the wounds clean so that they might heal quickly and well.

From very early times doctors had tried to find a way of dulling pain while operations, such as taking off an arm or a leg, were being performed. The best thing they could do was to use a drug like opium to make the patient drowsy. It was less than a hundred years ago that a plan was discovered for making the patient quite unconscious without endangering his life.

The first step in that direction was made when Humphry Davy, the great English chemist, discovered "laughing gas." He made this discovery in 1799, when only twenty-one years of age. He found that, by inhaling, or breathing in, nitrous oxide gas, he went into a strange kind of sleep in which he had very lively dreams—hence the name "laughing gas." He suggested that this gas might be used by doctors for the purpose of dulling pain in operations, but many years passed before this was done. The first to make use of laughing gas in this way was an American dentist, Horace Wells of Boston. But another and more important discovery was made in 1847 by a young Scottish doctor, James Simpson.

James Simpson was born at Bathgate, Linlithgow. His father was a baker, and James was the youngest of seven sons. When he went at the age of four to the village school, he showed such extraordinary quickness in his first lessons that his father and his elder brothers agreed to deny themselves all but the barest necessities of life in order to save money to send James to the University at Edinburgh.

When he was fourteen, he entered classes at the

University, a very young and very lonely little student. He worked hard, fully repaying the sacrifices his father and brothers had made for him. In 1832, when he was only twenty-one years of age, he took his degree as Doctor of Medicine. His talent attracted the attention of one of the professors at the University, and he was offered an assistant professorship. He became a full professor in 1840.

In 1846, Simpson heard that two Americans were experimenting with a gas called sulphuric ether as an anæsthetic, that is, a drug producing temporary loss of feeling while an operation is being done. Simpson was greatly interested, but felt sure that there must be something that would be easier to use, and that did not require such a heavy and clumsy apparatus.

He began to experiment with chloroform, which had been used as a medicine for some years. His idea was to inhale it, that is, breathe it in, not to take it. He invited two of his friends, Keith and Duncan, to join him in an experiment which took place in Simpson's dining-room.

The three men inhaled the chloroform, and in a few minutes they slid from their chairs and lay unconscious under the dining-table. A little later Simpson's butler came in, but he was not alarmed; he merely thought that his master and his friends had been drinking too much wine—not an uncommon thing in those days—so he loosened their collars and left them. When Simpson and his companions came to their senses, they were quite satisfied with their experiment; as Simpson said, "a glorious forward stride in science had been made."

Soon afterwards Simpson gave a demonstration of his discovery at the Edinburgh Royal Infirmary, but there were many old-fashioned people who did not approve of it, and some even said that it was contrary to Bible

teaching. But, after a hard fight, chloroform came into general use and saved untold suffering.

James Simpson was made a baronet and became a Royal Physician.

Lord Lister.

Joseph Lister was born at Upton in Essex. His father, by business a wine merchant, took a great interest in natural history, and spent much of his spare time in working out improvements in the microscope. It is not surprising that young Joseph loved natural history. Even as a schoolboy, he was always collecting and preparing specimens, in which he was encouraged and helped by his father.

When still at school, Joseph made up his mind to be a surgeon, and, having taken his degree, he continued at University College, London, as a medical student. The medical school was at that time quite small, for it had been founded only twenty years.

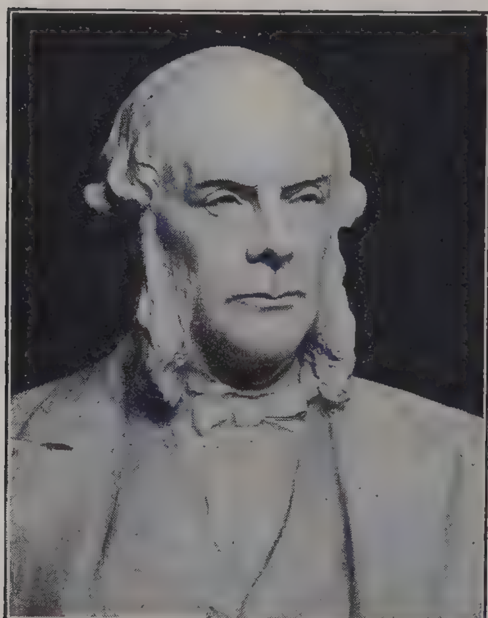
In 1853, Lister went to Scotland and worked in the hospitals, first in Edinburgh, then in Glasgow. He was very much distressed at the number of deaths that followed injuries and operations. At first he could not understand the reason.

At this time Pasteur was working in France, making his wonderful discoveries about germs. Lister became very much interested in the great Frenchman's work, and at last he was certain that so much suffering and so many deaths were caused by those living germs in the air, and not the air itself. He guessed that these germs entered the wound and poisoned it, or, as we say, made it septic.

Then Lister knew that he must find a way by which these harmful germs could be destroyed. There were

three means of doing so—heat, filtration, and chemicals. He saw that chemicals were the only possible means that he could use.

Next, he set to work to find chemicals that could be used in dressing the wounds, to destroy the harmful germs. He was very careful that the hands of the operator and dresser, as well as the instruments used, were very clean; the wound was washed with carbolic acid, then clean cotton wool was used to keep any fresh germs away. Chemicals used for this purpose are called antiseptics.



Lord Lister.
National Portrait Gallery.

Lister's methods were so successful that in the hospital wards under his care septic diseases rarely occurred. By using the new method, it was possible to do many things that could not have been done in the old way; life was saved, and much suffering was avoided.

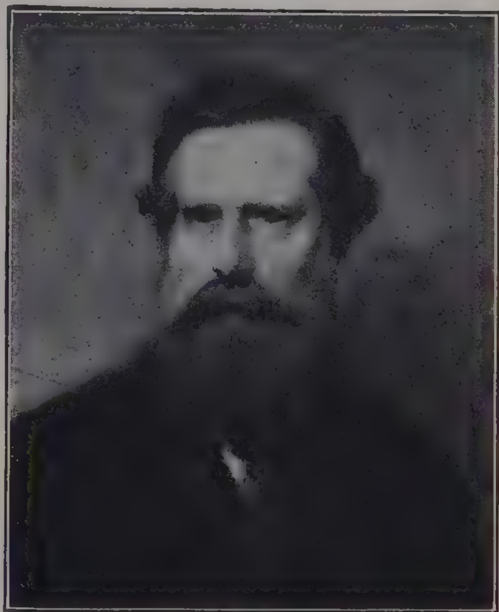
The older surgeons were not very ready to follow Lister's ideas, but his own pupils were eager to do so, and his methods were adopted by surgeons in France and Germany.

Of Joseph Lister it was said, "He has saved more lives than all the wars of the ages have thrown away."

(*d*) Röntgen and X rays.

Another great scientist who ranks with Louis Pasteur and Joseph Lister as a benefactor to sufferers, is Wilhelm Konrad Röntgen. He discovered the "X" rays, and gave men quite new ideas in scientific study.

Röntgen was born at Lennep, in Rhenish Prussia, and became Professor of Physics at Würzburg University in 1885. Ten years later he made his great discovery.



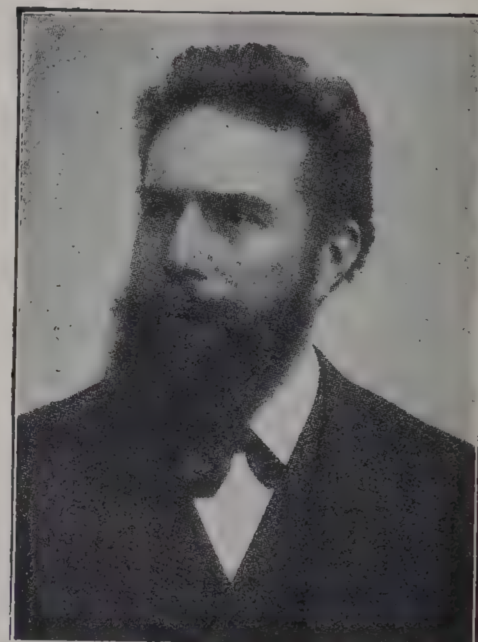
Sir William Crookes.
National Portrait Gallery.

Röntgen's discovery would not have been made but for the previous discovery of a Manchester man, Mr. William Thomson, who found that some chemical substances glowed brightly under the influence of an electrical discharge. Another great scientist, Sir William Crookes, heard of Thomson's discovery, and visited him. Later, Sir William made some "cathode tubes" containing these substances.

Röntgen was experimenting with one of these Crookes tubes at the time of the discovery. He had wrapped up the tube in black paper to prevent its light from being seen, when to his surprise he noticed that a bit of cardboard on which were pasted some crystals (of barium platino-cyanide) glowed brightly. He at once guessed that some invisible rays were given out by the Crookes

tube, and these passed through the black paper to the cardboard screen.

He also noticed that on the light was a line of dark shadow, the shadow of the tube wrapped in black paper through which the rays had passed. In a further test the professor placed his hand between such a tube and the screen, and saw the shadow of the bones of his hand cast on the screen.



W. K. Röntgen.

Rischgitz.

He said nothing about his discovery at the time, as he wished to be quite sure of his facts. After a time he told it to a scientific society at Würzburg. He named the rays "X" rays, because he was not able to say exactly what they were, and mathematicians use this letter as a symbol for an unknown quantity.

Within forty-eight hours of Röntgen's lecture at Würzburg news of his discovery had been telegraphed to England, and at least three English experimenters had taken X-ray photographs of the bones of the human hand. The first real use of the rays on a large scale was in the South African war (1899–1902).

During the World War (1914–1918) X-ray photography was largely used, and, by showing where splinters of shrapnel were, it helped the doctors to save the lives of thousands of wounded soldiers. X-ray apparatus now

forms an indispensable part of the equipment of every up-to-date hospital.

In cases of broken bones, an X-ray photograph shows the doctor exactly where the break has taken place, and treatment can be applied without unnecessary suffering.

An X-ray photograph. The arrow points to a small fracture of one of the bones of the finger.

E.N.A.

X rays may be dangerous as well as useful. They can destroy parts of the body exposed too long or too often to their power. In the early days of their use, X-ray operators suffered loss of fingers, and not a few lost their lives in trying to help others. The dangers, however, are being overcome, and it has been found possible to use the destructive power of the rays to destroy diseased tissues in the human body.

These wonderful rays are used for many things besides surgery. By their help photographs have been made of so delicate a structure as apple blossom, while they can also be used to show flaws in a steel casting three inches in thickness.

(*e*) The Wonders of Radium.

MONSIEUR CURIE (1859–1906) and MADAME CURIE (1867–).

One of the wonders of modern science is the magic metal known as radium. It is the most costly thing in existence because it is so very, very scarce.

You may have seen watches with "luminous dials," by which you can tell the time in the dark. Some of these watches have the figures and hands painted with a kind of radium paint, though the cheaper ones may be only treated with phosphorus. Radium paint is made from a chemical such as zinc sulphate with just a tiny speck of radium mixed with it. A bit of radium the size of a pin's head is enough to make shining paint for a very large number of watches.

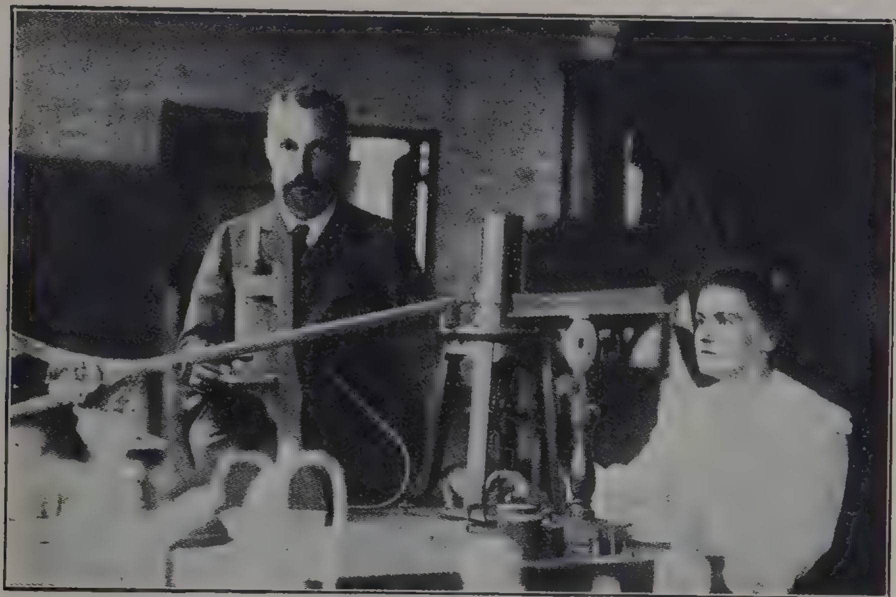
If you look at one of the radium-painted watches through a very powerful microscope, you will see tiny flashes of light. These flashes, which take place at the rate of several thousand a second, are caused by the breaking up of the radium atom. The particles of the radium atom strike the zinc sulphate or other chemical mixed with it, and cause the spots of light to appear.

The zinc will wear out after a few years, but radium itself will last almost for ever. All the time it is giving out light and heat, yet it does not seem to lose weight. We call this wonderful power radio-activity. Nearly every object that comes in contact with radium becomes for a time radio-active.

Radium has been known only just over thirty years, but it has already become very useful. Its most valuable use is in treating certain kinds of disease. Every large hospital has a small stock of radium. It is very expensive, because it is so very scarce. One milligram costs £25 to £30; and a milligram is $\frac{3}{200}$ of a grain! But doctors need only a tiny speck, which is fitted into a fine tube or needle. The needle is used for pricking diseased tissues in a patient's body in the hope of destroying them, and preventing the disease from spreading to healthy tissues. Except in very tiny quantities radium is very harmful, and has to be very carefully handled.

Now let us see how radium was discovered.

After Röntgen's discovery of X rays in 1895, a great French scientist, Henri Becquerel, was making tests with certain things that are said to be phosphorescent, that is, they shine or glow (like phosphorus) without seeming to



M. and Mme. Curie photographed in their laboratory, while engaged on the work that led to the discovery of radium in 1898.

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be hot. He discovered another kind of rays—Becquerel rays—somewhat like X rays, but not quite the same. These rays came from a certain substance obtained from pitchblende. It is called uranium.

The work begun by Professor Becquerel was carried on by Pierre and Marie Curie. Marie was a Pole, born at Warsaw, but she went to Paris to study science. In 1895, she married a clever French scientist, Dr. Pierre Curie. After Becquerel's discovery the Curies began to study radio-active substances. They found that the radio-activity of some pitchblende was greater than that

of uranium itself, so they decided that there must be something else in pitchblende more powerful than uranium. They determined to find this substance.

Not being rich people, they could not go to much expense in their research; and they did the work in an old shed with a leaking roof, and with the roughest of apparatus. For years they worked hard, treating and separating large quantities of pitchblende sent to them from the Austrian mines. Then they found a new substance something like uranium, but different. Madame Curie called it "polonium" after her native land, Poland.

But they were not satisfied. They were sure that there was still something to be discovered. At last they found another new substance, more radio-active than anything yet known. They called it radium.

In 1903, the Curies, in company with Henri Becquerel, were given the Nobel Prize, worth several thousands of pounds. In the same year Madame Curie was made a doctor of science. In 1905, Pierre Curie was elected to the Academy of Sciences in Paris. Early the following year he was run over by a dray and killed instantly. In 1906 Madame Curie took her husband's place as professor at the Paris University.

The effect of radium on the human body was discovered by accident in 1901. Professor Becquerel had been showing a small tube of radium at a lecture. Afterwards he put it into his waistcoat pocket. About a fortnight later the skin under the pocket became red, as though it had been burnt; a deep and painful sore formed, and it took many weeks to heal.

During the World War, Madame Curie did great work by arranging a supply of radium for the hospitals, and she directed the Curie Laboratory in Paris. In 1921, President Harding, on behalf of the women of the United

States, presented Madame Curie with a gramme (about $\frac{1}{30}$ ounce) of radium in recognition of her wonderful work.

To obtain one thimbleful of radium it is necessary to treat a trainload of pitchblende. The ore has to go through some five thousand different stages, and the work takes six months to complete. But when the radium has been separated, it is almost everlasting. It will go on giving out light and heat for thousands and thousands of years, and at last it will change into common lead.

Questions.

1. What was Dr. Jenner's great discovery? What led him to make it? How did he apply his discovery?
2. What work did Pasteur do in France, and to what discoveries did it lead him?
3. How is Pasteur's work carried on to-day?
4. What did Simpson and Lister do for medical science?
5. What was Röntgen's great discovery? In what way was it accidental? Of what use is it to-day?
6. Who first discovered radio-activity? How did the Curies continue his work?
7. Say what you know of radium. Of what use is it? Why is it valuable?
8. What do you know of researches being carried on to-day in connection with the conquest of pain and disease?

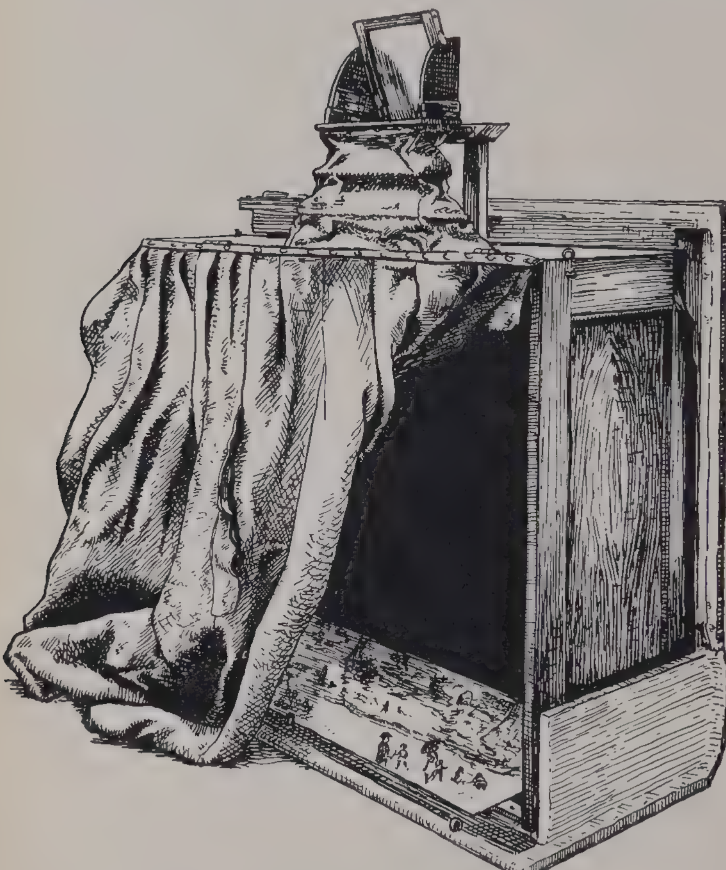
19. THE STORY OF PHOTOGRAPHY.

(*a*) The Camera.

If you examine a modern camera, you will find there is a little hole or window covered by a shutter. This shutter has to be moved up or down, and, while the little window is open, the picture is taken on the film or plate at the back of the box. In a "*snap*-shot" the shutter, after being opened, closes again automatically.

But in a " *time*-exposure " the shutter remains open until closed by the photographer.

Inside the little window is the lens, the most important part of the camera. A good picture cannot be made if the camera has a poor lens.



An early Camera Obscura.

Courtesy of Science Museum.

The first cameras were quite different from these. The term "camera obscura" (Latin for " dark chamber ") was applied to them. The dark chamber had one opening; inside the opening was a convex lens and a sloping mirror. The image of an object outside the chamber was received by the lens, and reflected by the mirror upon a white surface.

Now make these little tests for yourself. Hold a page of this book in front of a mirror; you will find it is reflected with the lines of print and the printed letters the wrong way round. Now place a lens or an ordinary reading glass in front of a lighted lamp; hold a piece of paper upright

at a suitable distance so that the rays from the lamp will pass through the lens to the paper. You will find the image of the lamp thrown on the paper, but it will be upside down.

Now place a piece of paper in a horizontal position, and hold a hand mirror in a sloping position (about 45°) behind the lens, so as to reflect the rays of light; you will now get a clear upright image of the object thrown upon the paper.

The camera obscura was employed in sketching from nature. The image of the object thrown on the paper could be traced with a pencil. Astronomers, too, found it useful. Some used it for watching the spots on the sun; others employed it for observing the diameters of the sun and moon.

A portable "dark chamber" was often needed, and in a book of the early seventeenth century we read of a dark tent fitted with a lens and a mirror, while in another book, written towards the end of the century, we read of a box with a projecting tube containing the lens.

The *magic lantern* is really a form of the camera obscura, and a modern development of it is seen in the *periscope* used by the men in submarines.

But the camera obscura only reflected the object; it could not make a picture; neither can a camera, unless we put in a film or plate.

(*b*) Thomas Wedgwood (1771–1805).

One of the pioneers of photography was Thomas Wedgwood, a son of Josiah Wedgwood, the famous potter.

The chemists of the eighteenth century noticed, as they worked with various chemicals, that a substance called silver chloride was darkened when exposed to the rays of the sun. In 1801, Thomas Wedgwood published an

account of some experiments carried out by himself and Sir Humphry Davy.

He showed that white paper, or white leather, moistened with silver nitrate, remained unchanged while kept in a dark place, but, when placed in the light, it darkened, becoming first grey, then brown, and at length nearly black.

Wedgwood described his method of using this paper by throwing shadows on it. These impressions remained for a short time and then gradually faded away, while the unexposed parts became tinged with brown; for it was very difficult to wash away all the tiny grains of the silver nitrate. The next step, therefore, was to find a way of fixing the impression.

(*c*) The First Sun Picture.

Joseph Niepce (1765–1833).
Louis Jacques Daguerre (1789–1851).

It was a Frenchman, Joseph Niepce, who made the first sun picture. Niepce was an officer in the French army, but retired on account of bad health. He returned to his native town, Châlons-sur-Sâone, and took up chemical and mechanical experiments. He was much interested in the new art of lithography, producing pictures by tracing on stone and then printing off on paper. In 1813, he began to work on a new idea, that of printing a picture by means of the sun's rays.

He wanted to make a copy of an engraving, and he did it in this way. He varnished the wrong side of the print to make it transparent. Then he placed it on a sheet of metal covered with a black substance called bitumen. The dark parts of the picture kept the rays of the sun from reaching the plate, while the lighter parts let them through. He fixed the print by soaking it in a mixture of oil of lavender and petroleum. This dissolved the

parts unaffected by light, and the picture formed of modified bitumen remained.

It took ten hours for the sun to make an impression on the bitumen-covered plate, so Niepce could not take a photograph of anybody.

Another Frenchman, Louis Daguerre, was making similar experiments at the same time. Daguerre was a Parisian scene-painter. He invented the "diorama," which was very popular in England as well as in France. It consisted of a set of large, transparent, coloured pictures of scenery; and when these were exhibited in a darkened room with a light behind them, the effect was beautifully realistic.

In the course of his work with this invention, Daguerre became interested in the effect of light on different materials. When he heard of Niepce's success in copying a picture with the aid of the sun's rays, and fixing the image, he at once hurried to Châlons to find out more about the method. As a result of this visit, the two men entered into a partnership, and continued to make experiments.

It was a long time before they were able to make a rapid and lasting picture. First they used iodine instead of bitumen. That was better, but the pictures were still faint and hazy. Then a lucky chance taught them a better way to develop their pictures.

One night Daguerre placed some undeveloped silver plates in a cupboard. When he took them out the next morning, he found the pictures had developed themselves as if by magic, and were much clearer than any he had developed in the ordinary way.

He felt sure that this was the work of one of the chemicals in the cupboard. Which was the wonder-worker? One by one, he tested the effect of each chemical

on other plates, until he proved that mercury had done the work. From that time, the progress of photography was rapid, and people were able to have their photographs taken. The pictures, called daguerrotypes after the inventor, were much darker than the present-day photographs.

Other men were making trials and experiments at the same time, and in 1839, the year in which Daguerre made known his discovery, an Englishman, Mr. Fox Talbot, made further improvements. He followed the Wedgwood plan of treating paper with silver nitrate and common salt. By means of a very simple camera he took views of his house, and claimed them as the first photographs made of a building.

Niepce used little cameras, about six inches square, fitted with a tube and lens. Some of them may be seen in the museum at Châlons. Other experimenters made cameras from cigar boxes, using a spectacle or opera glass for the lens.

In 1847, glass plates were introduced, and the camera itself began to improve rapidly. But, as photography became more and more popular, hand cameras were in demand, and it was now necessary to find something less heavy and brittle than the glass plates. After many experiments the Eastman Company, in 1887, brought out the Kodak camera, with a celluloid film.

During the last thirty years photography has become more and more wonderful. The use of X rays in photography has already been mentioned ; it is also now possible to photograph objects in their natural colours. The use of the camera in connection with aircraft, both in ordinary surveying and in warfare, is most important. And to-day, " the pictures " are, without question, the most popular outcome of modern photography.

(*d*) The Cinema—" Moving Pictures."

About a hundred years ago a kind of toy was made that was called the zoetrope or " wheel of life." It was a hollow cylinder fixed on an upright axis. There were slits in the sides of the cylinder, and inside it was pasted a series of pictures, usually showing a man on a galloping horse, or some such moving objects. As the cylinder was spun round, anyone looking into the slits saw the horse apparently moving, or the men running, jumping, or dancing. What really happened was that the pictures moved before the eye so quickly as to appear to be a single " moving " picture.

At first these pictures had to be drawn by hand, but when photography could be used much better results were possible. In 1877, a series of pictures of a galloping horse was made by using a row of cameras, the shutters of which were opened and closed by electricity as the horse passed in front of them.

The first exhibition of " moving pictures " was given in London in 1885. A London photographer, Mr. Friese Green, made a continuous ring of small pictures printed on glass. When these were made to revolve round a light, and the magnified pictures thrown on to a screen, the figures appeared to move. The audience was delighted and astonished at the show.

But these little glass photographs were clumsy and easily broken. To get a life-like picture, it was necessary to take from sixteen to fifty photographs a second; so, for an entertainment lasting an hour, 50,000 to 165,000 pictures would be necessary.

Inventors began to try other materials instead of glass, and at last hit upon celluloid. Celluloid is made from camphor and guncotton; it is light and strong, and can be used in the form of a roll film. Its great disadvantage

is that it quickly catches fire, and burns very fiercely. Inventors are now trying to overcome this danger.

With the invention of the celluloid film to take the place of the glass plates, it was possible to improve "moving pictures." In 1895, in London, an exhibition was given with pictures not unlike those we see in the cinema to-day. But the first "moving pictures" were often full of cracks and holes; they were hazy and blotchy, while the lamp flickered badly, and made the eyes of the audience ache. The actors and actresses who acted for the story films, were not used to performing without speaking, and the result was rather stiff and stupid. But, although less than forty years have passed since the first cinema show, the invention has made wonderful progress. There are few towns of any size without at least one picture house—some have a great many—and a visit to "the pictures" is part of the life of most town folk.

Now the gramophone has been brought into use in connection with film-production, and we have "talking pictures" as well as "moving pictures."

Questions.

1. Exactly what occurs when a photograph is taken? Why would not the camera obscura take photographs?

2. How, and in what order, were the discoveries made with regard to the first photographs?

3. What is meant by developing and printing photographs?

4. How did the idea of the cinema first occur to inventors? What took the place of glass for films, and what is still its grave defect?

5. Make a list of the best educational films you have seen, or heard of. Classify your list according to subjects. Describe briefly one you have seen.

20. A GREAT AMERICAN INVENTOR.

Thomas Alva Edison (1847–1931).

The Telegraph—Electric Lamps—Phonographs.

(*a*) A Boy who Wanted to Know.

Thomas Edison, one of the greatest inventors of the nineteenth and twentieth centuries, was born at Milan, Ohio, in 1847. When he was seven years old, his parents moved to Port Huron, Michigan.

As a child Thomas was so unlike other children that he was called " queer." He asked questions till older people were tired, and even then did not believe what was told him, but wanted to find out for himself. His teachers lost all patience with him, and at last his mother, who had been a schoolmistress, undertook to teach him herself. Together they read large numbers of books, big, thick volumes such as were published in those days. His father encouraged him by paying him a small sum for every good book he read.

But, although Thomas loved reading, he found plenty of time for getting into mischief. Once he fell into the canal, and was nearly drowned. At another time he fell into his father's grain elevator, and was almost smothered. He lost the tip of a finger, when holding a skate strap while another boy cut it with an axe. On another occasion he made a fire on the floor of a barn. The building was burnt down, and Thomas was publicly whipped as a punishment.

When he was twelve years old, Thomas made up his mind to become a newsboy on the train between Port Huron and Detroit. His mother did not wish him to do so, but he had his way. He made eight to ten dollars a day by selling papers. Sometimes he had special news

telegraphed ahead, and put on the notice boards at the stations; this made the people eager to buy his papers when the train arrived.

In the afternoon he had time to spare between trains, and this he spent in Detroit Public Library, reading books about science. He was much interested in electricity, and, with the help of a chum, he managed to fix a telegraph line between their homes. The line was made of glass bottles and stove-pipe wire. After a time it was carried off by an old cow, but not before the lads had learned something of telegraphy. In the cellar of his house Thomas had a stock of bottles labelled "Poison" to prevent people from meddling with them.

It was Edison's love for experiments that ended his career as a newsboy. One day, while he was performing an experiment in the guard's van, he set fire to it. An angry conductor threw him off the train at the next station, after having boxed his ears so sharply that he always remained somewhat deaf. Edison then became a telegraph operator, but often neglected his work to carry on his studies and experiments in electricity.

In 1869, Edison was out of work, and went to New York penniless, but got a job at the Gold Reporting Company. Three days later there was trouble in the office. The telegraph instrument had broken down. Soon clerks from other offices were crowding in to say they could get no replies to their calls. The proper operator was so worried that he could do nothing, but Edison, who guessed what was wrong with the instrument, offered to put it right. His offer was gladly accepted, and in two hours the wires were working again. The newcomer was called into the chief's office, and offered charge of all the instruments in the building at a salary of 300 dollars a month.

Edison still worked at his experiments, and invented a number of improvements and devices that were very useful to his employers. A few years later, he was asked by the head of the company to name a price for the whole of his inventions. At first he thought of saying, "5,000 dollars"; but this seemed such a large sum that he was afraid. He was just going to say, "3,000 dollars," when the chief asked, "How would 40,000 dollars do?"

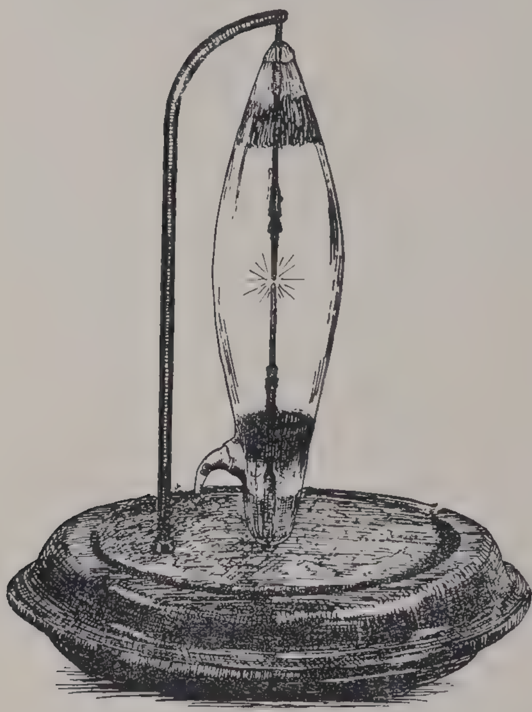
He took the cheque and left the office quite bewildered at his good fortune. This money was, of course, of great help to him in his work. One could fill a whole book with the story of Edison's inventions; for he is said to have taken out over fifteen hundred patents. You shall hear about two of them.

(*b*) Edison's Electric Lamp.

By the middle of the nineteenth century men had found electricity very useful in many ways; but it could not be used for lighting ordinary houses, because no suitable lamp had been invented, and no means of measuring the quantity of electricity used had been thought of. Edison supplied both these needs.

The arc lamp was at that time the only kind of electric lamp in use. You remember that Sir Humphry Davy made an electric lamp in 1808, but found the wires were quickly burnt up. After that a substance was found that would conduct electricity well, and stand the heat. This was a very hard black substance found at the bottom of the crucibles used for making gas, and so called "gas carbon." It was cut into small rods, and the flame was allowed to play between the ends of two such rods. An electric arc lamp is the most brilliant light that can be made, but it is too brilliant for general use.

Edison wanted to find a lamp that could be used in an ordinary room. He knew that when an electric current is sent through a wire, the wire becomes red hot, or even white hot, and therefore gives a light less glaring than the arc lamp. He tried burning wires in air, but they soon gave out. Even when he burnt them in a globe that had been emptied of air, they did not last long.

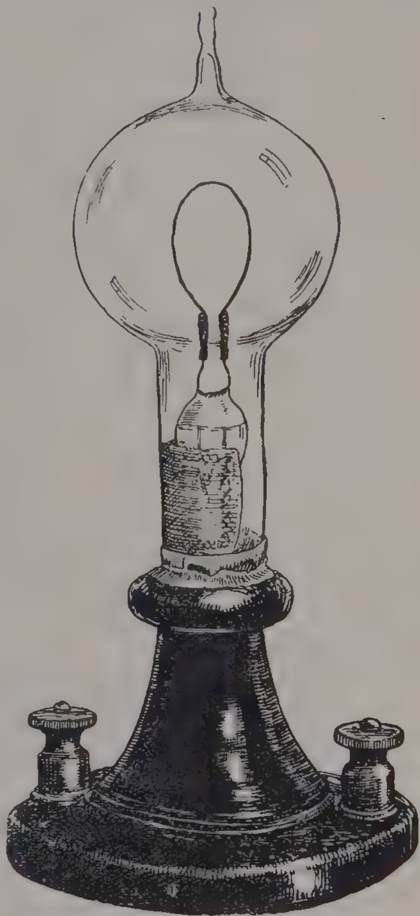


Swan experimental Carbon-pencil Lamp.
Science Museum.

Then he began to try experiments with carbon, but soon found that it could not be drawn out into a fine wire. His next plan was to treat thread with great heat until it was changed into carbon. He tried threads of cotton, silk, flax, and bamboo, and found that bamboo was the strongest, but he was not yet satisfied.

While Edison was working in America, a noted inventor named Joseph Swan was trying to do the same thing in England; and both happened to make a good thread at the same time. Edison made a thread from lamp black and tar, while Swan produced one by soaking a carbon thread in sulphuric acid. Both patented their inventions, and for a time they were rivals, but in the end they became friends, and worked together. The lamps they made bore the trade-name "Ediswan," which, of course, is a combination of their two names.

Later on, they made a better thread from a pasty substance called cellulose, a mixture of cotton wool and chloride of zinc. This can be forced by pressure through a very small hole, and so drawn out into a fine thread. The thread is then blackened by heating in a crucible.



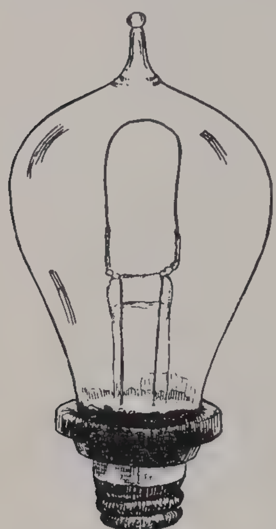
An early experimental Edison Lamp.
Science Museum.

The filament, as the thread is now called, is then enclosed in a glass globe where not a trace of air can get near it. If the smallest quantity of air were to get in contact with the filament while it is glowing, it would burn up at once. The most difficult thing is to mount the filament in the globe and to conduct a current through it from the outside.

This is done by melting thin platinum wire into the glass ; for platinum is the only wire which will not break the glass. When platinum is heated, it expands in the same way and to the same extent as the glass, and therefore does not break away from it. The filament is joined to the platinum wires by a special cement. After all this has been done, the air is pumped out, and the globe is melted off the pump at the lower end, where a little point of glass is seen.

Edison spent 100,000 dollars on his experiments before

he made a really successful lamp. For three years he sold the lamps at less than they cost him to make, but in 1880 he and his partner Mr. Swan were able to make and sell the lamps at a profit, and the great demand made up for their former losses.



Commercial
Bamboo-filament Lamp.
Science Museum.

Edison followed up this success by inventions for supplying electric current to buildings, and by making meters for measuring the quantity of electricity used. From this time electric lighting became possible for ordinary houses, as well as for such purposes as lighting the lighthouses.

(*c*) Edison's "Talking Machine."

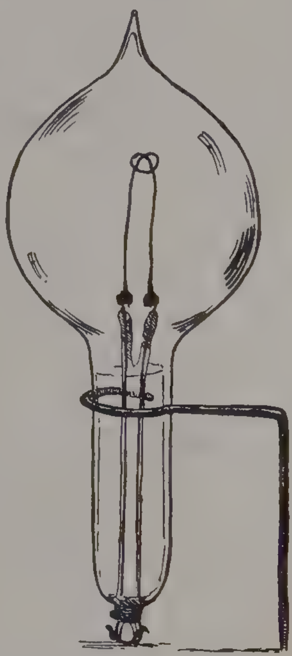
About the same time that Edison was experimenting with his electric lamp, he very much amused the men in his workshop by telling them that he meant to make a talking machine that would reproduce words spoken, and not only reproduce them, but enable them to be stored for use again and again when required.

Although the people of fifty years ago laughed at the idea, and said it could not be done, Edison *did* it. At first he tried round plates or discs, such as are used to-day in our gramophones, but at that time these were not successful. Then he used a cylinder that had been wrapped in tinfoil. As a person sang or spoke into the machine, the voice caused movements or vibrations in the air. The vibrations moved a marker in the machine, and caused it to make little dents on the tin foil. In this way the first records of the human voice were made.

The cylinder or record was placed in a machine called

a phonograph. The machine turned the cylinder round, and the listener, having placed the ear-pieces of two long tubes in his ears, heard the song or speech repeated by the "talking machine."

When a new idea has thus been got into working order, it is easy to improve on it. Edison himself made many improvements during the next ten years, and at last succeeded in making wax discs do the work instead of the unsatisfactory tin cylinder. During this time another inventor, Emile Berliner, a German living in America, patented a similar instrument called the gramophone.



Swan early commercial type of Lamp.
Science Museum.

Soon the tubes and ear-pieces were replaced by large horns, so that everyone in the room might be able to listen at the same time; and, later, the horns were done away with, for the improved mechanism of the instrument made them no longer necessary. Portable gramophones are now very popular, as they can easily be carried from place to place.

There are few houses in these days where there is not a gramophone, and records can be had of songs by great singers, and speeches by famous men. These records will be stored up, and people in years to come will be able to listen to them.

(*d*) The "Talkies."

Edison had been among the early experimenters in photography. In 1893, he was exhibiting a kind of

penny-in-the-slot peep show at an exhibition in Chicago. Looking into this, one saw a series of small photographs passing so rapidly that the people seemed to be moving. He had already tried to invent a photographic film, but

Thomas Alva Edison photographed in his study, with one of his Phonographs.

E.N.A.

the Eastman Kodak Company brought out one before his was quite ready.

He was greatly interested in the progress of the cinema. In 1913, he gave the first display of "talking pictures" by using the phonograph together with the cinematograph. Shortly after this, the World War began, and the inventor turned his attention to the manufacture of chemicals and other things needed when the United States entered the War.

Few other inventors, if any, have been engaged in so

many different kinds of work as Thomas Edison, or have lived to see their inventions in such general use in all parts of the civilized world.

Questions.

1. Write an account of Edison's boyhood. How did the opportunity first come to him to show his inventive genius?
2. What is an Ediswan lamp?
3. Upon what principles was the first phonograph constructed?
4. How was this developed into the gramophone?
5. What do you know of recent improvements in gramophones?

21. BICYCLE TO MOTOR-CAR.

(*a*) Early Ideas for Cycles.

The story of the bicycle, like that of the motor-car, is not the story of one or two great inventors, but of the inventions and improvements devised by numbers of men who were gradually building up these useful means of conveyance.

The idea of using some kind of machine made of two wheels, and worked by the rider, seems to be very ancient. In pictures of life in ancient Babylon and Egypt, and also in Pompeii, there are suggestions that the idea was known to these clever people of long, long ago. But it was not until the nineteenth century that it was really worked out so as to become of general use.

In the seventeenth and eighteenth centuries a few experiments were made. In 1690, a Frenchman named De Sivrac designed a machine consisting of two wheels, one in front of the other, connected by a wooden bar. The rider sat astride the bar, and moved himself along by pushing against the ground with his feet. The idea was revived in 1779 under the name of the *velocipede*.

The next step was the invention, in 1817, by Baron Karl Drais von Sauerbronn of a machine called, after him, the *draisine*. In this machine the front wheel was pivoted on the frame so that it could be turned sideways by means of the handle, thus serving to steer the machine.

The Hobby-horse, or Velocipede.

The *draisine* became popular in England under various names, such as dandy-horse, hobby-horse, bicipede, and velocipede. But the plan of pushing with the foot was said to injure the legs, so inventors began to look for a better way of propelling the machine. Although it was found that the front wheel might be turned by hand, the idea of using pedals worked by the feet was not thought of for many years.

A Bone-shaker.

A Scottish blacksmith named McMillan is said to have fitted pedals to a tricycle in 1834, while another Scotsman, Gavin Dalzell, ten years later, used pedals on a *draisine*, which had two wooden wheels, forty inches and thirty inches respectively in diameter, with iron tyres.

In 1865, a Frenchman, Pierre Lallement, living in Paris, made a machine in which the front wheel was driven by pedals and cranks fastened directly to its axle. It is doubtful whether the idea was really Lallement's

own, or whether he got it from the son of his employer, who was a coach repairer. The machine was made of wood with iron tyres. He took it to America, and was granted a patent. It was called the bicycle (i.e. the two-wheeled) by those who really thought it would be useful, but other people called it the "bone-shaker."

A "Penny-farthing" Bicycle.

By and by solid rubber tyres took the place of the iron ones. These were very large, sometimes two inches or more in width. Other changes followed; the front wheel became bigger, the back wheel smaller, and wire spokes were used.

In 1869, the manufacture of bicycles was begun in England by the Coventry Sewing Machine Company, large makers of sewing machines, and from that time Coventry became the home of bicycle manufacture.

The popular form of bicycle at that time was known as the "penny farthing," because the front wheel was so much bigger than the back one. These bicycles made great speed, but they needed very rapid pedalling, and there was great danger of the rider being thrown over the handle-bar by any unexpected jerk. On one of these machines, in April, 1884, Thomas Stevens started from San Francisco to ride round the world, and he completed his long journey in December, 1886.

In 1885, J. K. Starley, of Coventry, brought out the "Rover," a machine with two almost equal wheels; and, three years later, pneumatic tyres were invented by J. B. Dunlop, a veterinary surgeon of Belfast. Many other improvements followed, including that of the

"free wheel," which allows the rider to "coast" down hill, using his pedals as foot-rests.

(*b*) Tyres and Pumps.

Nearly every new invention makes another invention necessary. The pneumatic tyres were a great improvement on the old solid tyres, so far as comfort for the rider was concerned. But, as you know, they sometimes suffer from a puncture. Then the air leaks out, and the tyre becomes flat. So the invention of these tyres made some kind of pump necessary in order that air could be forced into them.

An early Safety Bicycle with solid rubber tyres.

At first there were only large, heavy pumps, much too big and clumsy to carry about, so whenever a cyclist wanted his tyre pumped up, he had to go to a bicycle shop and get it done. This often meant a long walk and waste of time. Then various kinds of hand-pumps were tried before a really satisfactory one was made. Now we have the light, handy kind that can easily be fastened to the machine for use at any time.

Here is a true story of how a bicycle pump once saved a man's life. A missionary in West Africa had a bicycle sent to him from England. He was cycling along a lonely road, one day, when he was suddenly set upon by a band of fierce natives belonging to an up-country tribe He had no gun to defend himself with, but he unfastened his bicycle pump, pointed it towards the men, and pumped as hard as he could. The natives had never seen anything

like it before, and they thought that the white man was practising magic upon them. With cries of terror, they fled back into the bushes, and the missionary went on his way without further trouble.

(*c*) Motor-cycles and Motor-cars.

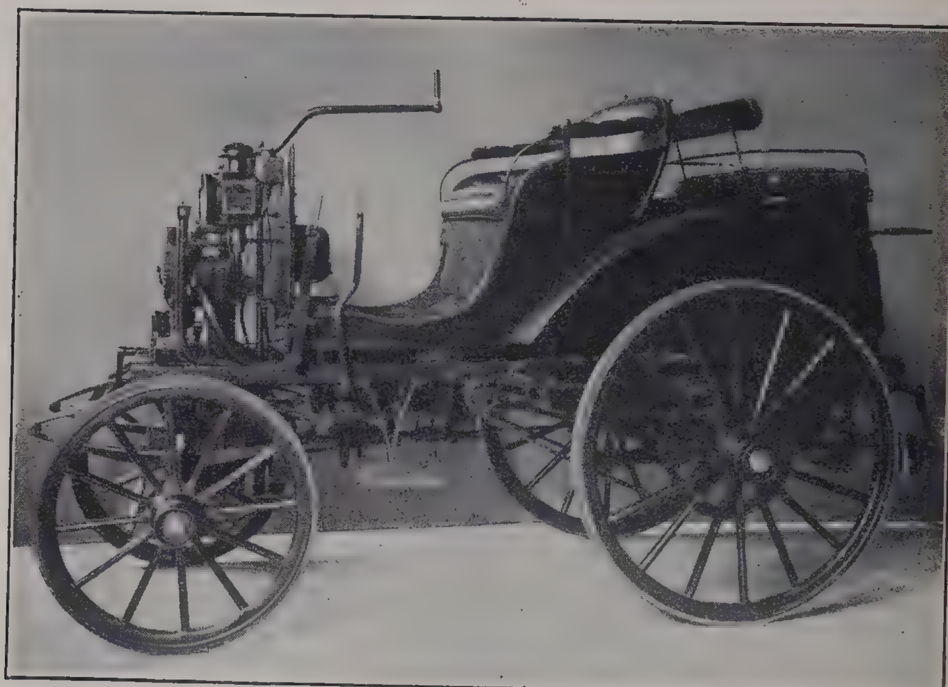
Mankind is never satisfied. Bicycles were useful, but they were not always suitable for a traveller's needs. Railway trains were useful too, but even now many places cannot be reached by train. So inventors turned back to the old idea of an engine-driven carriage for use on the roads.

You will remember that Richard Trevithick tried to run a steam carriage, but found the roads too bad for such a vehicle. Roads in the late nineteenth century were very much better, but men had learnt more about steam, and had decided that, except for steam traction engines, a steam carriage was not suitable for use on the roads. Then they began to work on an engine driven by petrol. Petrol, or gasolene as it is called in some countries, is the refined spirit obtained from a mineral oil called petroleum.

The first successful petrol engine was made in 1885 by a German, Gottlieb Daimler. He fitted one of his engines, or motors, to a bicycle. Two years later, at the time of the Paris Exhibition, he had one in use in a boat running on the River Seine. This attracted the notice of a French firm, Panhard and Levassor, who saw that the idea might be used for driving a road carriage.

The great advantages of the petrol engine over the steam engine are the ease with which the fuel can be put in, and the fact that it does not need a lot of engineering skill to manage it. For nine years French firms spent large sums of money on the task of experimenting with,

and improving, the automobile, as motors were then called. The earliest types of cars were noisy, clumsy, queer-looking things. Most of them were able to seat only one person; others could carry two or even three people.

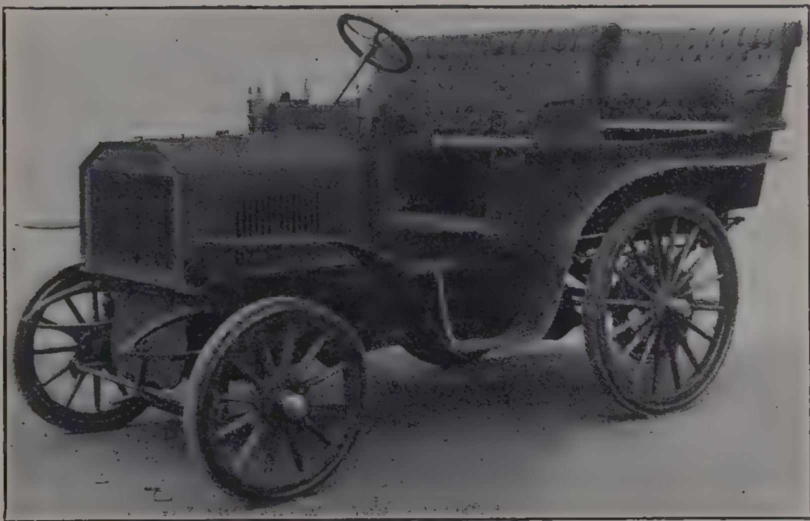


A Panhard Motor-car, 1894.

Courtesy of Science Museum.

In England, during the early days of the nineteenth century, a few attempts had been made to run steam carriages on the roads; but, in 1865, an Act of Parliament was passed that required three persons to drive the locomotive, and a man carrying a red flag to walk in front. At the same time it was forbidden that the engine should blow off steam, or exceed a speed of four miles an hour. In 1881, a Mr. Bateman fitted a tiny steam engine to a tricycle, but he was told that the law applied

to his machine just as much as it did to the heavy traction engines. In spite of this, a few men did try various types of little steam carriages, while, in 1885, an inventor named Butler, made an engine driven by oil vapour and fitted it to a tricycle. It was not until the old Act was



An early Daimler motor-car, 1898. Note the very great improvement that had been made in the short space of four years. This car shows that the basis of present-day styles had already been established.

done away with, in 1896, that motors could be used on English roads.

Meanwhile, in 1894, a French newspaper arranged a trial run of motors from Paris to Rouen. The winning car attained a speed of twelve miles an hour, which is the greatest speed permitted to-day for a London bus in a busy thoroughfare. The following year, in a run from Paris to Bordeaux, the winning car made an average of fifteen miles an hour. The first Englishman to win a motor trophy was Mr. S. F. Edge, in an international race from Paris to Vienna, in 1902.

The use of motor-cars increased as improvements of

all kinds were made in their construction. Cars were made suitable for all kinds of work. To-day there are light little cars that can cross the sand of the Sahara Desert, and heavy lorries that can be used for all kinds of transport. Between 1910 and the outbreak of the Great War in 1914, the motor-bus and charabanc had become familiar, though not so numerous as they are now.

Sir Henry Seagrave. *E.N.A.*

During the war the motor-lorry was found to be the best means of carrying troops; but, on one occasion, in 1914, when it was necessary to move sixty thousand troops forty miles in one night, in order to make a surprise attack on the advancing Germans, the business was carried out by means of taxi-cabs.

The motor-bicycle also played an important part in the War, and was used by dispatch riders.

As motor traffic increased, the roads required improvement. At first the dust was a great nuisance to people walking, and to those living in houses by the roadside. This has been largely overcome by the process of tar-spraying the surface. New roads have been made, and old roads widened.

In the manufacture of the cars, steel of a light but strong quality is needed; and, by studying the various steel alloys (mixtures with other metals), the manufacturers have produced substances of great strength and

lightness. There are now in Great Britain alone well over two million motor vehicles.

The use of motor-buses has now become general, and many country villages have been put within easy reach of towns. Goods can be carried more easily by motor-lorry than by goods train, as the goods are taken direct to their destination without shifting to and from railway trucks. Every year new improvements are being made.

Sir Malcolm Campbell.
E.N.A.

In 1927, thirty-three years after the first motor trial run, a British motorist, Major (afterwards Sir Henry) Seagrave, broke the world's record for speed in a Sunbeam car at Daytona Beach, Florida. His car attained a speed of over two hundred and three miles an hour. In February, 1931, Captain (afterwards Sir Malcolm) Campbell achieved a new record by travelling at a speed of two hundred and forty-six miles an hour. This record he again broke in February, 1932, when he reached a speed just short of two hundred and fifty-four miles an hour, and again in September, 1935, with a speed of three hundred and one miles per hour.

Questions.

1. Describe some of the early bicycles. Illustrate your answer.
2. What improvements were first made in bicycles?
3. When was the petrol engine first used? By whom, and how?
4. Describe the early motor-cars, and give drawings.

22. MARCONI AND "WIRELESS."

(*a*) Telegraphy without Wires.

Early Efforts.

Before you read the story of Marconi, the world-famous inventor of the Marconi system of wireless telegraphy, you must hear something about the men who first tried to work out the idea of sending messages without wires.

In the early days of telegraphy it seemed to some people nothing short of magic that messages could be sent along wires from town to town, hundreds of miles apart ; then came the wonder of the ocean cable, carrying messages from continent to continent, and then that of the telephone, carrying the actual sound of the speaker's voice to the listener, miles away. These things had once seemed fairy tales, but they had come true. Still men sought something more.

When the telephone was first introduced, many people thought the wire was a tube through which the sound travelled. What really happens is that the wire carries an electrical current, the strength of which is modified by the speaker's voice. Ingenious men of science wondered whether such electrical vibrations could pass through space without wires. Would this ever be found out ? How could the sounds be picked up ? Such questions puzzled man long before Marconi was born.

The first step was to pass a message through water without a wire. This was done in 1842 by Samuel Morse, one of the pioneers of telegraphy. Twelve years later, a Scotsman, James Lindsay, made a similar experiment by sending a message through the waters of the

River Tay, where the stream was three-quarters of a mile wide, and again at a place where it was two miles wide.

Other experimenters managed to set up communication with lighthouses, where, owing to the rough seas, an ordinary submarine cable would be quickly broken. Others suggested the advantage of some form of telegraphic communication between ships at sea. In America, in 1885, the busy inventor, Thomas Edison, worked out a plan for sending messages to moving trains.

All this time men were learning more about the air. They had made experiments with balloons, and had discovered that the atmosphere, that is, the air we breathe, extends no great distance from the surface of the earth. They were puzzled to explain how the heat and light from the sun reach us through space.

Then they came to believe that all space is filled with *ether*, a mysterious something of extreme rarity or thinness, and also of extreme elasticity. It is by no means the same as the air we breathe, but is the supposed medium through which light, heat, and electricity are transmitted.

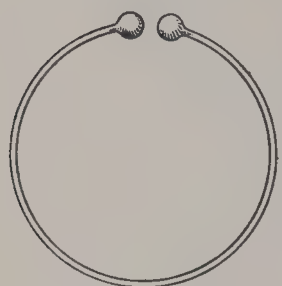
An English professor, James Clerk Maxwell, as a result of mathematical calculations, felt sure that electrical waves could be produced in the ether, and that, if they could be detected, it would be found they travelled as quickly as a ray of light; but he did not actually make the waves. Sir Oliver Lodge, Professor Hughes, and Sir William Preece studied these things in England, but it was a German who settled the question.

(*b*) Heinrich Hertz (1857–1894).

In 1888, a young German professor, Heinrich Hertz, made a great discovery, or rather, proved what Professor

Clerk Maxwell had believed to be true. He found a way of detecting the waves in the ether by means of a resonator. A resonator is a piece of wire at each end of which is a ball, and the wire is curved to form almost a circle, bringing the balls very close together.

Professor Hertz found that a spark of electricity caused waves in the ether to radiate in circles, like the rings you see on the surface of a pond when a stone is thrown into the water. He could detect these waves all around him by noting the small sparks jumping between the two balls of his resonator.



Hertz Resonator or Wave Detector.

He also placed a piece of zinc, eight feet square, on the wall opposite his wave-producing coil; this reflected the waves. The reflected waves were able to bring the original waves to a standstill, and then no sparks appeared between the balls of the resonator. In this way he was able to measure the distance between one wave and the next, and, in other words, to find the wave-length.

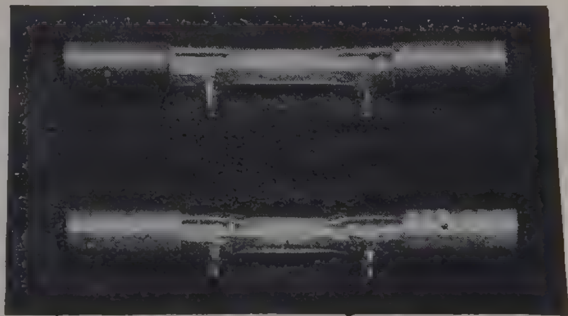
We now know that light is a very rapid wave movement in space; heat waves are less rapid; and electrical waves are very long. It is the last-named waves—Hertzian waves, as we call them—that are used in wireless telegraphy.

(*c*) Marconi (1874-).

Among those who read books and lectures on this subject was an Italian professor, named Righi. He began making experiments for himself, and, in his turn, interested one of his pupils at Bologna, named Guglielmo (William) Marconi.

Marconi was the son of an Italian father and an

Irish mother. He was a mere lad when he began to experiment with wireless telegraphy. His first tests were across a room, then across the garden of his father's house at Bologna. He used tin boxes set up on poles in the ground. He made electricity in a battery, and radiated it from a wire hanging from a tall pole. He turned on and shut off the current with a key like that used for telegraph instruments, and he used the Morse alphabet for his messages.



Coherers used in Wireless Detection.

Courtesy of Science Museum.

It was fairly easy to send out messages into the ether, but it was not so easy to find a way of picking them up. A French professor named Branly had invented an instrument called a coherer. Marconi improved this and used it in his experiments. A coherer is a glass tube about the size of a pencil, and about half as long. The ends are filled with silver, and in a narrow space in the middle of the tube is some metallic powder. When an electric wave passes through such powder, the particles cohere or stick together, and then the powder conducts the current easily.

Marconi connected a battery to two wires in the ends of the coherer, and as soon as the wave reached the wire, and the coherer began to conduct it, a current from the battery passed through and worked an ordinary telegraph apparatus. When the coherer was shaken or tapped, the particles were separated, and it was ready to receive the next wave. Marconi had a little hammer tapping the

coherer at short intervals, to keep it ready to receive a wave.

In 1896, Marconi came to England, and took out his first patent for wireless telegraphy. Sir William Preece, the Chief Engineer of the Post Office, who had already made experiments of his own, became greatly interested in the young Italian inventor, and gave him much help, encouraging him and providing him with the means for continuing his researches and experiments.

The first wireless message Marconi sent in England was through a distance of twenty-five yards across the River Thames. Then he set up apparatus in London, and sent messages from one part of the city to another; for instance, from the General Post Office to the Savings Bank Department, in Queen Victoria Street.

Then he succeeded in sending a message a distance of four miles on Salisbury Plain, and later from Weston-super-Mare to Penarth, on the opposite side of the Bristol Channel, a distance of between eight and nine miles. For these long-distance messages the wire had to be taken very high into the air, and this was done by means of kites.

In 1897, while on a visit to his native land, Marconi was able to set up communication between two warships, nearly twelve miles apart. On his return to England, he set up two wireless stations, one at Alum Bay, in the Isle of Wight, the other on the mainland at Bournemouth.

In the summer of 1898 Marconi was asked by the *Dublin Daily Express* to send, from the sea, wireless reports of Kingstown Regatta. The steamer, *Flying Huntress*, was engaged to carry the sea-going apparatus which was set up in the cabin of the vessel. For several days reports were sent constantly from the steamer to the land station, whence they were telephoned to the office of the newspaper.

Another chance for proving the value of wireless telegraphy occurred a month later. The Prince of Wales (afterwards King Edward VII) met with an accident to his knee on board the royal yacht *Osborne*. Queen Victoria, who was staying at her house in the Isle of Wight, wished to be able to communicate with the Prince, and wireless apparatus was set up by which a hundred and fifty messages were successfully transmitted in a fortnight.


The first "Wireless" Station, Poldhu, Cornwall.

The following year, a message was sent across the English Channel to France, a distance of thirty-two miles. In 1901, Marconi began preparations to send a wireless message across the Atlantic. A wireless station was erected at Poldhu, in Cornwall, and another at Cape Cod, on the coast of Massachusetts, U.S.A.

In September the Poldhu masts and aerial were wrecked by a storm, and it was two months before they could be re-erected and got ready for use. The Cape Cod station had also suffered, so Marconi, with two assistants, went to Newfoundland, to set up a temporary receiving station at St. John's.

By the end of November the station was ready. It was not intended to reply to any signals received, but the operators at the Poldhu station were told to commence

on the 11th of December to send, during certain hours every day, a succession of S's, followed by a short message. The S in the Morse code is three dots equally distanced. This signal is very distinct, and cannot be confused with any natural atmospheric sounds.

Marconi in the cabin of his famous yacht *Electra*. The cabin is full of wireless instruments which Marconi uses for experiments when at sea.

E.N.A.

On December 12th Marconi and Kemp, one of his assistants, were waiting in the little room at St. John's. On the table was the receiving apparatus; a wire led from the instrument to a very large kite that was flying in the wind about four hundred feet above. Marconi had had great difficulty with his kite; one kite and a balloon had been carried out to sea, but now this one was flying bravely.

Suddenly Marconi called to Kemp, and, handing him the receiver, asked if he heard anything. Kemp listened eagerly, and then replied that he could hear quite distinctly the three sharp clicks of the S's. The short message that followed could not be received, probably because the kite aerial did not remain at a constant height, but a great victory had been won—the Atlantic not only

carried a submarine cable between the Old World and the New, but it had now been bridged, as it were, by wireless telegraphy.

A year later Marconi had set up regular communication between Nova Scotia and England; and, in 1903, President Roosevelt sent the first official message from the United States to King Edward VII.

Many improvements were carried out between 1903 and 1914. Then the Great War began, and the invention was adapted to the needs of warfare. It proved very useful, especially in connection with warships, submarines, and aircraft.

After the War, "wireless" was put to a fresh use. The introduction of wireless telephony made it possible to broadcast to people who had installed receiving sets in their own homes.

(*d*) Broadcasting.

After the War, attempts were made in both England and America, to send out music from the wireless stations. At first gramophone records were used. These proved so successful that singers and musicians were engaged to give performances before the microphone in the wireless stations, and the music was then broadcast to listeners within the radius.

For a fortnight, from February 23rd to March 6th, 1920, a daily concert was broadcast from Chelmsford wireless station, and in June of that year Dame Nellie Melba sang in a broadcast concert that was listened to over a radius of three thousand miles.

In 1922, the British Broadcasting Company was formed for the purpose of arranging regular broadcasts of music, lectures, weather forecasts, market prices, and bulletins of news. The result of this was a great increase in the

number of receiving sets in use. In 1927 the B. B. Company came to an end, its place being taken by the British Broadcasting Corporation, under Government control. Every user of a wireless receiving set has to pay 10/- a

Front and back views of a broadcasting microphone. About one-third the actual size.
Courtesy of Science Museum.

year to the Postmaster General for a licence. The number of licences issued in 1936 was over 7,000,000.

(*e*) " Wireless " at Sea and in the Air.

Wireless telegraphy has proved very valuable in putting ships at sea in communication with shore stations and other ships. In 1909 the Government bought up all the " ship and shore stations " owned by the Marconi Company and Lloyd's. Three new stations have been

set up, making thirteen in all, and the service has been extended.

By an Act of Parliament (1919) it was made compulsory for all British sea-going ships over 1,600 tons to carry wireless apparatus, which is under the care of the

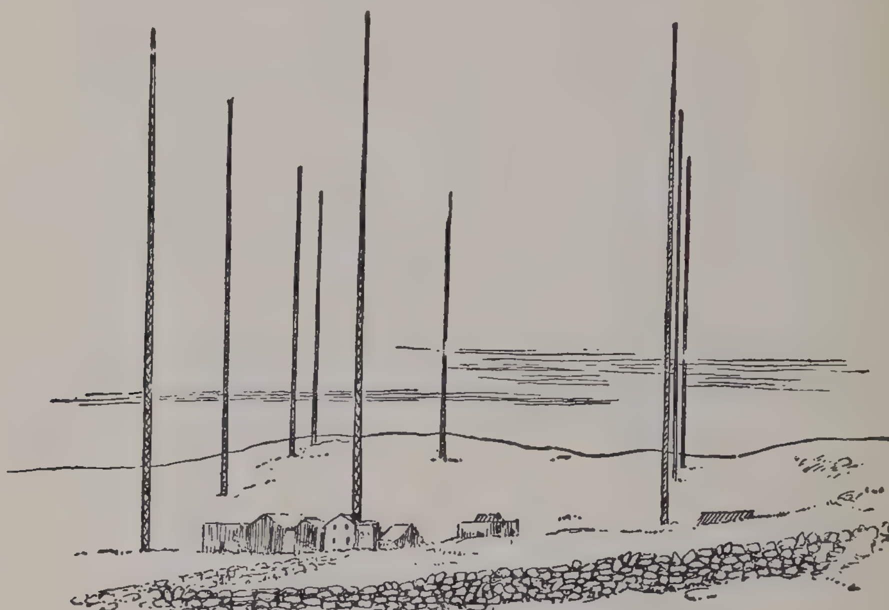
Brookman's Park (London) Broadcasting Station.
Courtesy of the B.B.C.

Postmaster General. It is now possible to broadcast from the super-power station, at Rugby, British official news, telegrams, and news messages to ships at sea in any part of the globe. In the case of fire, leak, or other disaster, messages can be flashed from the ship in distress in all directions. One of these messages will most certainly be picked up by another ship, or by a shore station, and help will be sent. In this way very many lives are being saved every year.

In connection with the use of "wireless" at sea, the signal of distress, S.O.S., has become so famous that the designation is now applied to other urgent calls for help. This signal was adopted because it is so simple and so unmistakable, three dots, three dashes, three dots.

"Wireless" has become most useful in aircraft. It is possible for an aeroplane or an airship that has lost its

bearings to get into wireless communication with Croydon or some other air station, and receive instructions as to the right direction to take. Gale warnings are sent out that prevent aircraft starting a flight, when bad weather conditions are threatening on the route.



" Wireless " Station, Caernarvon, Wales.

QUESTIONS.

1. What experimental steps led to the idea of wireless telegraphy? Name some of the experimenters.
2. Describe how the Atlantic was first " bridged " by wireless.
3. Of what practical use is wireless telegraphy?
4. Explain what is meant by the abbreviation " B.B.C."

23. PIONEERS OF AIRCRAFT.

(*a*) Learning to Fly.

For many centuries men longed to do a thing which seemed impossible—they wanted to fly. In the old

stories of gods and heroes the Greeks told of the winged shoes of Hermes, and of the way the gods and those whom they helped were able to fly through the air. But there were *men* who actually tried to fly.

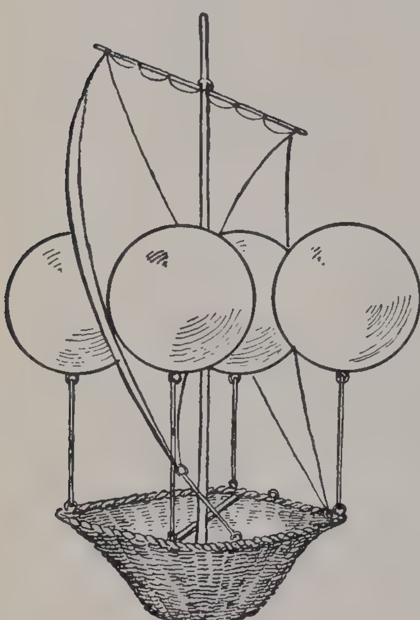
In Rome, during the first century after Christ, a man called Simon the Magician, who wanted to prove that there was nothing so very wonderful in the Ascension of our Lord, is said to have made a flying machine. We do not know what it was like, but we are told that he did go up " by the power of the devils," and then fell down and was killed.

Some centuries later, in Constantinople, a Saracen tried to fly. Wearing a " big robe, stiff with rods," he went to the top of a tower. Perhaps this robe was something of the same kind as the parachute used by airmen to-day, for the story says he could spread his robes like a fan. He was waiting for a favourable gust of wind, but the people who had gathered at the foot of the tower to watch him, grew impatient. " Fly ! " they shouted. " Hurry up ! Are you going to keep us waiting all day ? " The man, eager to please the crowd, jumped from the tower, but, although he did rise a few feet, his robe soon crumpled ; he crashed to the ground, and was killed.

Roger Bacon, who lived in the thirteenth century, declared that a flying machine would one day be made so that a man sitting in it might put in motion artificial wings, and beat the air like a bird flying. Four hundred years later, Francesco Lana, an Italian, who thought the air was something like water, suggested making an airship, fitted with four hollow copper globes, to be propelled by oars and sails. A picture of this impossible aircraft is found in a book published in 1670.

In 1676, a French locksmith named Besnier tried to fly. He made a curious machine with four paddles.

Each paddle or wing opened like a book as it went down, and closed on being pulled up. Cords tied to the man's ankles did the moving. It is said that Besnier went to a high place and flung himself into the air. He glided or flew safely to the ground. It is also said that he flew over a house and crossed a river.



Lana's Aeronautical Machine.

Many other queer and quite useless attempts were made from time to time, but without success, until two brothers, the Montgolfiers, made the first balloon.

(*b*) " The Bag of Smoke."

Joseph Montgolfier (1740–1810).
Stephen Montgolfier (1745–1799).

Stephen and Joseph Montgolfier lived at Annonay, in Auvergne, France; they were paper-makers as their forefathers had been. Their father was the first to make vellum paper in Britain.

One winter night the brothers were sitting together over the fire. After watching the smoke curling up the chimney, one of them exclaimed, " Why should not smoke be able to raise things into the air ? "

They decided to test this idea. Having made a large paper bag, they filled it with smoke by holding it over a dish containing burning paper. To their delight, the bag, when filled with smoke, became so light that it floated to the ceiling. Next, they made a very large bag, and repeated the test in the open air. When filled, the bag broke loose from the strings that held it, and floated

away to a great distance. Probably the Montgolfiers soon found out that it was not the smoke that raised the bag. It was the warm air that entered with the smoke; for warm air is lighter than cold air.

The next step was to fill the bag with gas instead of smoke or warm air. A gas called hydrogen was used, because it is very light. It was very expensive, however, for it had to be made from iron filings and sulphuric acid. On August 27th, 1783, the first gas-filled balloon, as it is now called, was sent up from Paris. Its gas-bag was made of silk, and took many days to fill. It rose to a height of three thousand feet in a few seconds, then it vanished into the clouds. After remaining in the air for three-quarters of an hour, the balloon came to earth in a field fifteen miles away.

Montgolfier's Balloon.

The villagers were terrified at this monster that had dropped from the skies. The gas inside the bag made it heave and move, so the frightened peasants felt sure the monster was alive, and hoped it would soon fly away again. After a while a farmer brought his gun, and fired at it. Then it began to shrink, so the crowd rushed upon it with flails and pitchforks. As they tore the silk, the gas came out, and the unpleasant smell (the gas not being pure) drove them back. At last they tied the balloon to a horse, but the animal took fright and galloped off, tearing the silk to shreds.

A few months later, two other Frenchmen made the first balloon voyage, and floated over the city of Paris.

In 1785, a Frenchman, named Blanchard, and an American, Dr. Jefferies, crossed the English Channel, from Dover to Calais, by balloon.

For a hundred years, the balloon was the only means of travelling in the air. The early balloonists had many thrilling adventures, and, in several cases, balloons drifted away with their passengers and were never again heard of. But, during the siege of Paris in 1870, sixty-five balloons left the city, carrying refugees and letters, and only two of these were lost.

Balloons have been very useful for testing the conditions of the atmosphere, and for surveying the country. During his 1901 expedition, Captain Scott made the first balloon ascent in the Antarctic regions.

Now we must turn to the story of modern aircraft—airships and aeroplanes.

(*c*) Gliders.

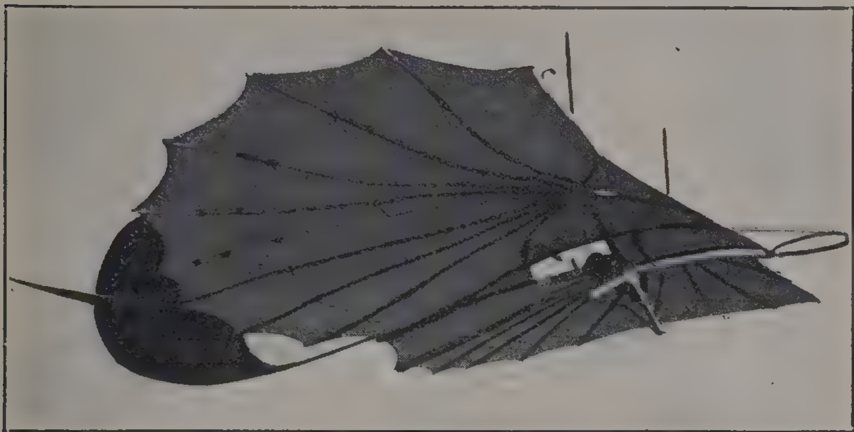
OTTO LILIENTHAL (1848–1896).
PERCY PILCHER (1866–1899).

Otto Lilienthal was a German. He and his brother Gustav spent many years in studying birds and experimenting in flying. In 1889, they published a book in which they showed that the kind of flight that might be imitated by machinery was not wing-flapping, but the soaring and gliding methods of certain birds that, with wings outstretched and apparently rigid, glide through the air. You will see this kind of flight, if you watch the gulls at the seaside.

The Lilienthals made a machine called a glider. It was a light wooden frame, covered with a thin fabric. There was a seat in the centre for the flier, and the contrivance was held in position by his arms. The weight of the machine was about forty pounds.

The glider guided his flight with his legs, hanging freely from the seat. In one of his machines Lilienthal had a small motor, but this was not satisfactory on account of its weight. In his later machines he had two wings, or planes, instead of one big one.

In 1896, just as his experiments were beginning to



A Lilienthal Glider, 1895. The control was effected by moving the body.

Courtesy of Science Museum.

attract the notice of scientific men in England, France, and America, Lilienthal was killed. He was experimenting near Berlin, and had flown a distance of twenty yards, when the wind caught his machine and carried him upward. He lost control and fell to the ground, breaking his back.

Percy Pilcher, a young English naval engineer, who had been appointed lecturer in naval construction and engineering at Glasgow University, became interested in Lilienthal's experiments. Having seen a picture of the German glider, he set to work to make one for himself. He called it the *Bat*. He went to Berlin to visit Lilienthal, and had several rides in the biplane glider.

Pilcher made two other machines, the *Gull* and the

Hawk, while in a fourth machine he fixed an oil engine, but this was never used in a flight.

In September, 1899, Pilcher promised to give an exhibition of gliding at Market Harborough, in Leicestershire. The *Hawk* and the new machine were taken into a field. Unfortunately it rained, and the gliders were soaked through. The *Hawk* was intended to rise from a level field, towed by a line over a pulley drawn by two horses. The machine rose easily; but the line snapped, and the glider came gently to the ground. Pilcher tried again, and was soaring at a height of about thirty feet, when one of the wires of the tail broke and the *Hawk* fell headlong. Pilcher was picked up unconscious, and died a few days later.

Otto Lilienthal and Percy Pilcher were the first real flying men. Gustav Lilienthal did very little gliding, but he continued to write on the subject.

(*d*) Airships.

Ferdinand von Zeppelin (1838–1917).

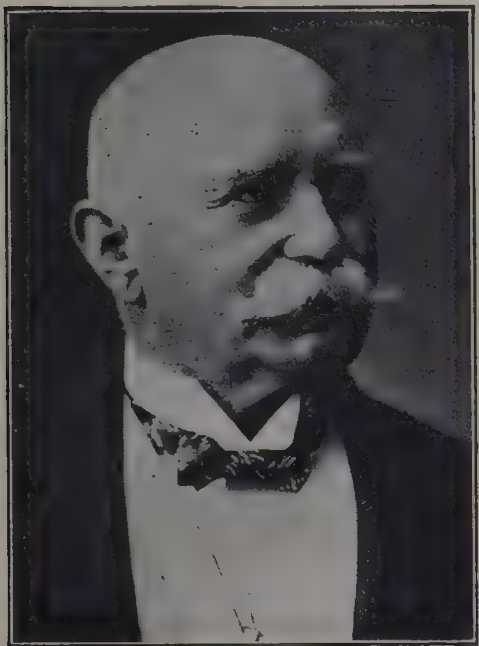
At the time of Lilienthal's experiments Germany did not favour the idea of flying, and yet it was another German who was one of the pioneers of the airship.

Ferdinand von Zeppelin began to take an interest in aircraft during the American Civil War (1861-5). He was then a young officer in the volunteer German corps fighting on the side of the Union, and, while with the army on the Mississippi, he made a few ascents in captive observation balloons.

On retiring from the army in 1891, he spent his time in the study and construction of airships. In 1895, he asked the German government for help in his work, but he was looked upon as a crank, and his plans were rejected

as useless. He then asked help from an American millionaire, the owner of a great newspaper, but the American replied that he had no time or money to waste on "crazy inventors."

But Zeppelin refused to be discouraged. In 1898, he started work on an airship, and, in 1900, his first airship was finished. Its total length was four hundred and twenty feet, and its diameter thirty-eight feet. It had an aluminium framework containing sixteen gas-bags. There were two cars attached, each containing a sixteen horse-power engine, and it could carry five men. Such a ship cost about £10,000. The airship rose from the ground, and remained in the air twenty minutes, but on landing it was wrecked.



Count von Zeppelin. *E.N.A.*

Still Zeppelin persevered, and, in 1906, he had another airship built, in which he made two successful flights at a speed of thirty miles an hour. Three years later he flew four hundred and seventy-five miles to Berlin.

During the great World War (1914–18), there were Zeppelin air raids over Britain. But, on the whole, airships, both German and British, have failed to come up to expectations, and some have had disastrous endings.

The *R 34*, the first lighter-than-air craft to achieve a direct trans-Atlantic flight. Length, 640 ft.; diameter, 79 ft.; capacity, 1,959,000 cu. ft.

Courtesy of Science Museum.

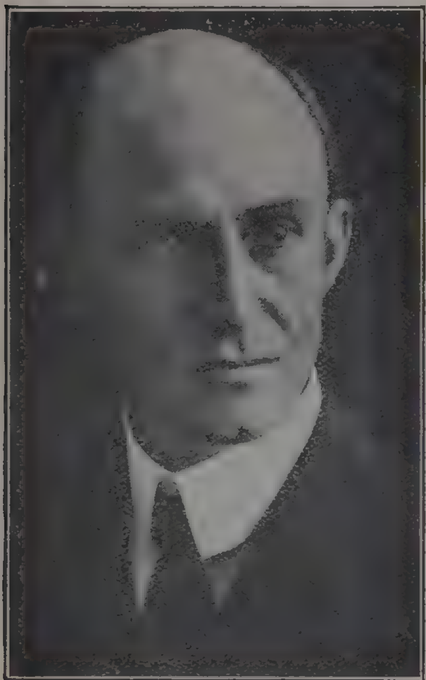
(*e*) Aeroplanes.

Wilbur Wright (1867–1912).
Orville Wright (1871–).
Henry Farman (1872–).
Louis Bleriot (1875–).

Two Americans, the famous Wright brothers, Wilbur and Orville, were among the pioneers of aeroplane construction. They were born at Millville, Indiana. When they were quite young, their father gave them a toy which they called the "bat." It was a frame of cork and bamboo covered with paper; when thrown into the air, it fluttered for a time before it fell to the ground. The toy was soon broken, but it was not quite forgotten. As they grew older, the boys were fond of kite-flying, though, at the time, they thought of it merely as a jolly pastime.

In the early nineties, the brothers opened a shop at Daytona, Ohio, for the repair of bicycles. About this time Lilienthal was killed, and in America experiments in flying were being made by Samuel Langley, a Washington professor, who had made a machine with large

outspreading wings and two propellers, driven by a small steam engine, but having no room for a man to ride. The Wright brothers became interested in these attempts, and began to make experiments for themselves.



Wilbur Wright. *E.N.A.*

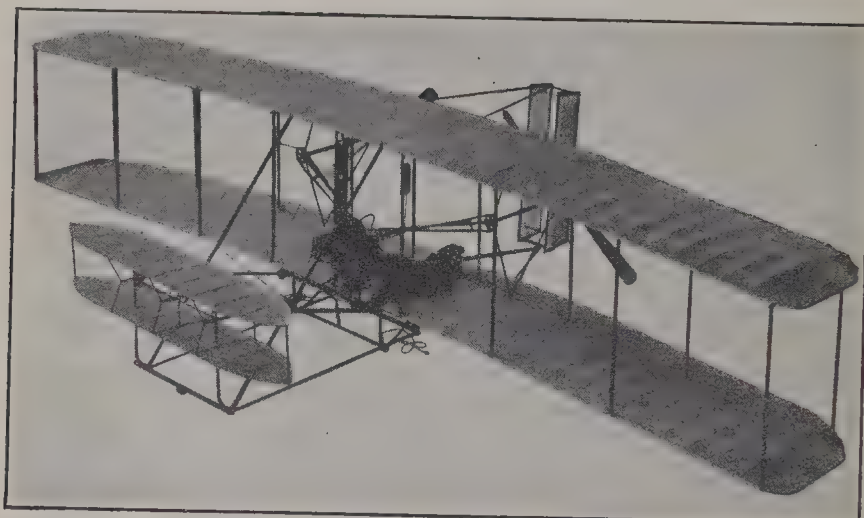
In 1903, they made a machine with a petrol motor, and carried out the first successful aeroplane flight. The machine flew two hundred

Orville Wright. *E.N.A.*

and sixty yards, carrying one of the brothers. Three other short flights were made the same day, so it was proved that a motor-driven machine could carry a man through the air. Two years later the Wrights made their first long flight of twenty-four miles at the rate of thirty-eight miles an hour.

As the Wrights could get no money for their invention in America, Wilbur went to France, and set up a school of flying at Pau. In 1908, he won the Michelin prize by

a flight of fifty-six miles. There is a little incident about this prize that shows the very real partnership which existed between the brothers. When Wilbur received his prize of £800, and had expressed his thanks, he at once divided the notes into two equal packets, and, without a



The original Wright Aeroplane, designed by the Brothers Wright, and flown by them on December 17, 1903.

Courtesy of Science Museum.

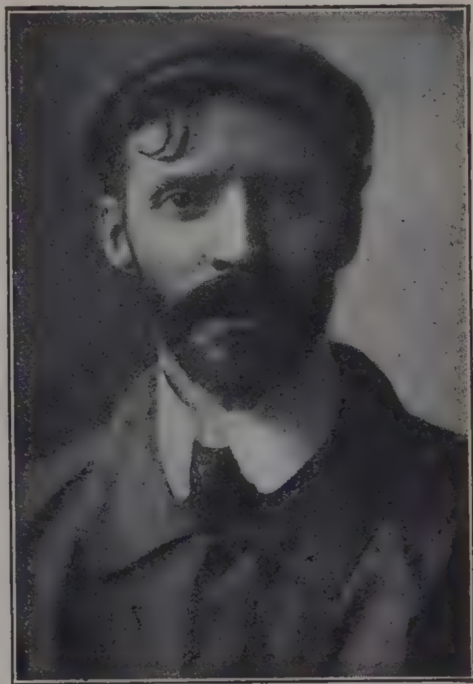
word, handed one packet to Orville, while he put the other in his pocket.

The invention of the brothers was at last recognized by their own nation, and the aeroplane was adopted for the United States army. Other countries honoured them also. Wilbur died in 1912, but Orville carries on the directorship of the Aeroplane Company which they had established at Daytona.

Another of the pioneers of aircraft is Henry Farman. Although the son of an English journalist, he was born and has lived all his life in France.

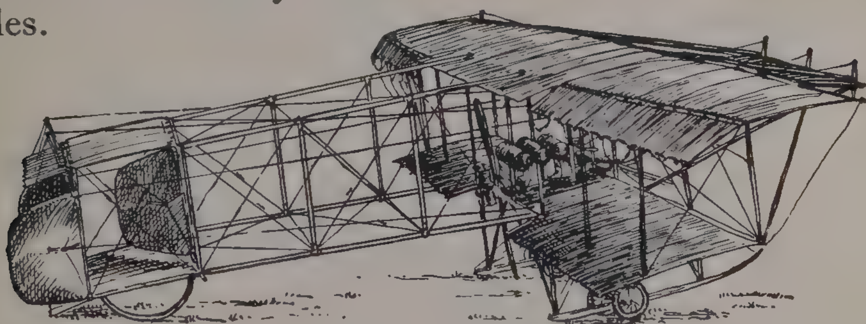
He began his career as a bicycle racer; then he went

into business as a manufacturer of bicycles and motor-cars. Later, when the interest in flying began to grow, Farman began to plan and build aeroplanes. He designed a biplane which bears his name. It has an eight-cylinder petrol engine.



Henry Farman. E.N.A

In 1908, Farman made several short flights, and in 1906 he won a prize of £2,000 for a circular flight of one kilometre (5/8 of a mile). In 1908, he was one of Wright's rivals in long-distance flights. He was the first man to fly from one town to another—from Châlons to Reims. In 1909, he won the Michelin Cup by a fine flight of a hundred and forty-seven miles.



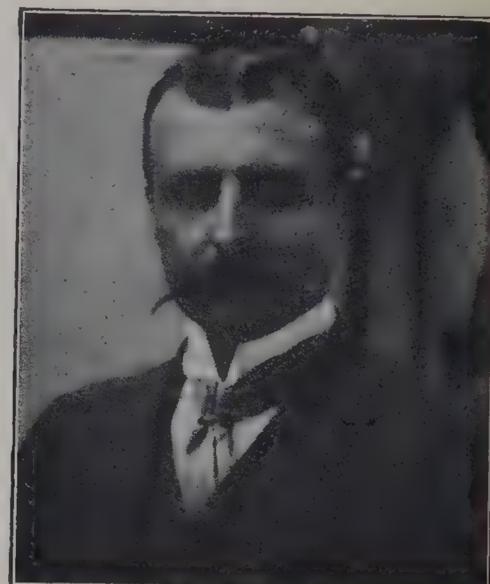
Model of a Farman Biplane.

Courtesy of Science Museum.

Louis Blériot, another Frenchman, had long cherished the ambition to fly. In 1900, he had made a model of a

"flapping-wing" machine, but it was not a success. He tried again and again, till, at last, he was successful.

His experimenting days were marked by success and disaster. A fine flight often ended in an unlucky landing. Machine after machine was wrecked, but although he had at least fifty accidents, Blériot himself always escaped with a few bruises and scratches, and was soon at work on another machine.



Louis Blériot.

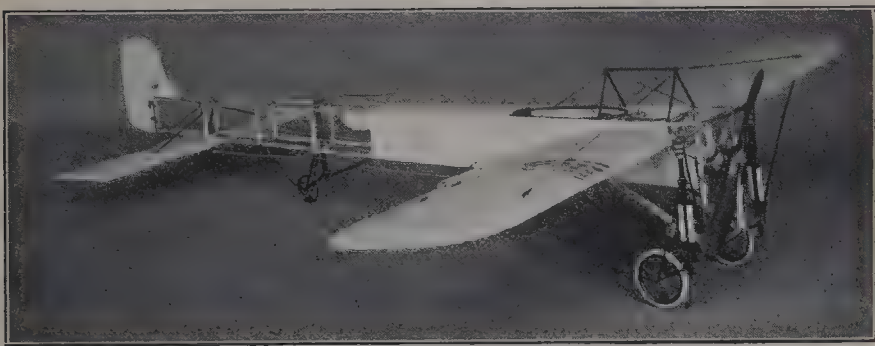
E.N.A.

In the great "flying year" of 1909 he flew from Etampes to Orleans, a distance of twenty-five miles. His little machine hopped over hedges and trees. The roar of the tiny engine alarmed passengers passing below in the Paris-to-Orleans express, and they gazed from the carriage windows in amazement at the wonder above their heads.

The *Daily Mail* at that time was offering a prize of £1,000 to the first airman who should cross the Channel. Hubert Latham, a Frenchman educated in England, made the first attempt, but failed. He came down on the water eight miles from the French coast, but the machine kept afloat and he was rescued.

Six days after Latham's failure, Sunday, July 25th, 1909, Blériot determined to try his luck. He was still lame from an accident a few days before, when he set out without a watch or compass to fly the Channel. His

machine was soon lost in a haze, but, fifty minutes after leaving France, he came out of the mist and sighted Deal. He flew along towards the cliffs of Dover, where he landed on a slope and crashed. Only one man, a French journalist, saw the landing.



Model of Blériot's monoplane.

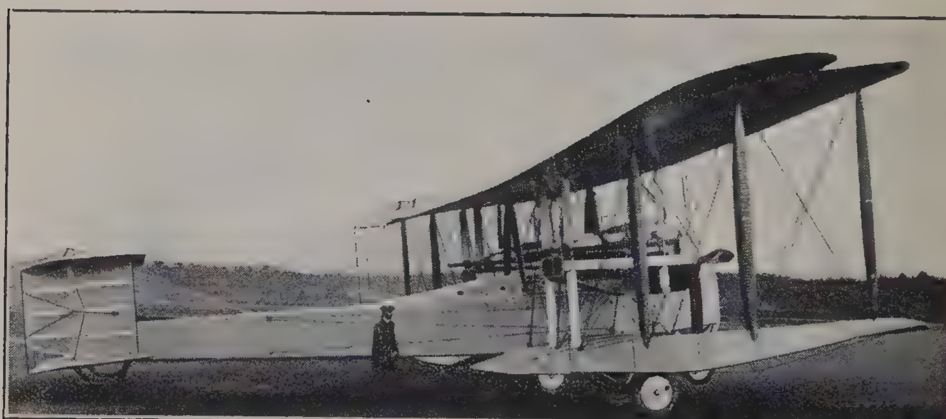
Courtesy of Science Museum.

When news of his feat was known, Blériot was the hero of the hour. He went to London, where he received a great welcome. His machine was exhibited, thousands of people paying for admission to see it. On the spot where he landed, a memorial in stone, taking the form of an aeroplane, was let into the turf. The machine itself was placed in a museum in Paris.

(*f*) Progress in Flying.

Not very many years have passed since Blériot flew the Channel, and in that time flying has made great progress In the Great War the daring and skill of the airmen were marvellous, and the aeroplane proved its great value. It was possible to make surveys and take photographs that were of immense help. But we will pass over those sad days, and see what advance has been made in the art of flying since the restoration of peace.

In 1919, two British airmen, John Alcock and Arthur Whitten Brown, flew across the Atlantic, and won the *Daily Mail* prize of £10,000, offered to the first airman to perform this feat. They left the American shore at five o'clock on a June evening. "As the light failed," says Alcock in his account of the flight, "worse conditions



The aeroplane in which the first direct trans-Atlantic flight was made, by Alcock and Brown.
Courtesy of Science Museum.

were encountered; clouds and fog became denser; eventually we were flying in a bank of fog. For seven hours we did not see sea or sky."

All that night and half the next day they tossed in their Vickers machine over the waters of the Atlantic, in the midst of fog, hail, and sleet. At last, quite suddenly, the masts of Clifden wireless station appeared—they had reached Ireland—they had won through. The airmen were knighted as well as awarded the *Daily Mail* prize. In December of the same year, unfortunately, Alcock was killed by the crashing of his machine at Côte d'Evrard, north of Rouen, in France.

In the same year Sir Ross Smith flew in stages from England to Australia, a distance of 11,295 miles, in a

hundred and twenty-four flying hours. Sir Alan Cobham has made several notable flights, to India, Cape Town, and Australia. Flights to the North Pole were made by Commander Byrd, an American, and also by the Norwegian explorer, Amundsen. The latter lost his life in an Arctic flight in 1928, while attempting to rescue another airman, Nobile, an Italian.

A "Moth" light aeroplane, the type of machine in which many of the pioneer long journeys have been made.

Courtesy of Science Museum.

In May, 1930, a young airwoman, Miss Amy Johnson, flew alone in a small Moth machine from England to Australia.

By adding floats, aeroplanes are converted into sea-planes, and are able "to take off" and alight on the water. As it is not advisable for planes to be exposed to much buffeting by the waves, a new type of naval-ship has come into use—an aircraft carrier—which has an extra deck for the planes.

The importance of aircraft for carrying passengers and mails is now recognized. In 1919, ten years after Blériot's cross-Channel flight, a converted war machine made the first flight of a daily service between London and Paris. This pioneer plane carried two passengers.

Passenger liners of Imperial Airways carry thirty-eight passengers and make six flights in each direction every day. It is now possible to leave London early in the morning, spend eight hours in Paris, and return the same evening.

The seaplane which won the Schneider Trophy on September 7, 1929, at an average speed of 328·63 miles an hour. It subsequently accomplished a speed of 357·7 miles an hour. A speed of 408·28 miles per hour was attained in September, 1931, with a similar type of machine.

Other air liners make daily journeys from Croydon Aerodrome to Belgium, Holland, Germany, Switzerland, and Sweden, and leave periodically for the more distant parts of the world.

It is said that London will soon be within fourteen days' travel of any part of the globe. Passengers will be able to reach Australia from England in eleven days, instead of taking twenty-eight days by water; and it will be possible to fly round the world in seventeen days. What would those people who were afraid of a railway train that travelled twenty miles an hour, say to speeding through the air at well over a hundred miles an hour, which is the usual rate for passenger-carrying aircraft?

Questions.

1. Describe some of the earliest attempts at flying.
2. Describe the ascent of the first gas-filled balloon, and its untimely end.
3. What did the Wright brothers do for aviation?
4. Who was the first to fly the Channel, and in what year?
5. Who were the first to fly the Atlantic, and in what year?
6. Name some of the pioneers in flying.

7. Obtain from the library *The Book of the Aeroplane*, by J. Laurence Pritchard, or some other book on flying, and read the account of Sir Ross Smith's flight to Australia.

8. Write a description of any great flight which has interested you.

9. What type of aircraft is most suitable for passenger flights? What do you know of passenger air-services?

10. What are the following:—The King's Cup, the Schneider Trophy, and the Aerial Derby?

General Questions.

1. Make a list in your notebook of the following words, giving their origin:—electricity, microbe, bacteria, Pasteurized, antiseptic, X rays, galvanized, voltage, telegraph, telephone, gramophone.

2. Make a list of inventors who gave their names to their inventions or new processes.

3. For what inventions are we indebted to Sir Humphry Davy?

4. "Men, my brothers, men the workers, ever reaping something new:
That which they have done but earnest of the things that they shall do."

These lines of Tennyson's appeared in 1842. Mention some modern inventions, which had not been heard of at that time.

For Girls:

1. How have modern inventions simplified the work of the home?

2. Read again the story of the first sewing machine.

SUGGESTIONS FOR ESSAYS OR LECTURETTES.

1. The Story of Cotton—from the plantation to the shop.

2. Spinning and Weaving in Legend and Fairy Tale: e.g. Arachne, the first spider; Penelope; Frigga of Scandinavia, the Queen of the Sky; the Lady of Shalott; the Sleeping Beauty.

3. The Industries or Work of your own district.

4. The Lighting System of your own town or village.

5. The Romance of Electricity.

6. The Autobiography of a Road—from Roman times to the present day.

7. Canals—including the Manchester Ship Canal, the Kiel Canal, the Panama and Suez Canals, the canals of Venice and Stockholm, and the canals of Holland.

8 A Visit to a Pottery.

9. "The old order changeth, yielding place to new."

10. The World in Fifty Years' time—as you imagine it.

11. The Invention in which you are most interested.

SUGGESTIONS FOR MAPS AND CHARTS.

1. In an outline map of England show, as they occur in your reading of this book, the following :—the cotton and woollen districts, the colliery districts, the Potteries, the Mersey and Manchester Ship Canal, the Stockton and Darlington Railway, the Liverpool and Manchester Railway, the chief lighthouses round the coast, the motor manufacturing towns, and the chief wireless stations and aerodromes.

2. By tracing, drawing, or cutting out appropriate pictures, prepare charts to show :—

(*a*) Changes in the methods of agriculture.

(*b*) Changes in iron-smelting.

(*c*) The growth of machinery in the cotton and woollen industries.

(*d*) Pottery through the ages—Bronze Age, and Celtic pottery, Roman and Romano-British pottery, Saxon pottery, and so on.

(*e*) The conquest of the sea—pictures of the Argo, Phœnician and Egyptian vessels, Roman galleys, Viking ships, the Santa Maria of Columbus, the Armada, and so on.

(*f*) The growth of the railways—pictures of the "Dragon," 1801; "Puffing Billy," 1812; "Blücher," 1814; "Rocket," 1829; and modern locomotives.

(*g*) Travel through the ages—chariots, Roman, Egyptian, and British; on horseback; the sedan chair, stage coach, and so forth.

(*h*) The growth of bridges and aqueducts—from old post bridges to the Tower Bridge, and the Menai and Clifton Suspension Bridges.

TIME CHART OF MODERN HISTORY.

	POLITICS.	INDUSTRIES AND INVENTIONS.
1688.	**William of Orange becomes king.** **William III** (1688–1702).	Savery's steam engine (1698). First Eddystone Lighthouse built by Winstanley (98).
1700.	**Queen Anne** (1702–1714). War of Spanish Succession (1702–1714). (Marlborough).	Jethro Tull's horse drill (1701). Winstanley perishes in destruction of lighthouse (03).
05.		Newcomen's engine (05). Second Eddystone completed by Rudyerd (09).
10.		
15.	**George I** (1714–1727).	
20.	Walpole, First Prime Minister (1721).	"Enclosures" proceeding.
25.	**George II** (1727–1760).	
30.		Kay's "Flying Shuttle" (33).
35.		Darby smelts iron by using coke (35).
40		Turnpike Acts.
45.	Prince Charles Edward's Rebellion (45).	Electricity carried across the Thames.

	Politics.	Industries and Inventions.
1750.		Franklin and Dalibard experiment with lightning (52).
55.		Rudyerd's lighthouse destroyed by fire (55). Smeaton's lighthouse built (1756–9).
	Clive in India—Battle of Plassey (57).	
	Wolfe in Canada—Quebec (59).	
60.	**George III** (1760–1820).	First lightning conductor (60). Brindley's first canal (61).
65.		Wedgwood "Queen's Potter" (65). Watt begins work on his steam-engine (65). Grand Trunk Canal begun (66). Hargreaves invents spinning jenny (67).
	Cook's first voyage to Australia (68).	Forth and Clyde Canal begun (68). Arkwright's spinning frame (69).
70.		
75.	American War of Independence (1775–83). Declaration of American Independence (76).	Watt goes to Soho (75). Watt's first engines sent out (76).
		Crompton's Mule (79).
80.		
		Montgolfier's first balloon sent up (83). Cartwright's power loom (84).
85.		Fitch experiments with a steamboat (87).
	French Revolution (89).	
90.		
	War with France (1793–1802).	Murdock experiments with gas lighting (92).
		Eli Whitney invents the cotton gin (94).
95.		Jenner's tests for vaccination (96).
	Rise of Napoleon—becomes First Consul (99)	Humphry Davy discovers "laughing gas" (99). Volta's electric battery (99).
1800.	First Factory Act (02). Treaty of Amiens (02). War with Napoleon (03–15). Napoleon proclaimed Emperor (04).	Trevithick's steam carriage (01). The steamboat *Charlotte Dundas* in use (01). Gas used at the Soho works (02).
05.		Fulton's steamship *Clermont* (07). Pall Mall lighted by gas (07).
10.		"Puffing Billy" of Wylam (12). Bell's steamboat *Comet* on the Clyde (12). First successful "sun pictures" (13). Stephenson's first engine at Killingworth (14).

	Politics.	Industries and Inventions.
1815.	Battle of Waterloo (15).	Oersted experiments with telegraphic needle. The "draisine" (17). *Savannah*, first ocean steamship (19).
20.	**George IV** (1820–30).	
25.		First railway (25). Telford's bridge over Menai Strait (25).
30.	**William IV** (1830–37). First Reform Bill (32). Abolition of Slavery in British Dominions (33).	Liverpool and Manchester Railway (30). Faraday's electric motor (31). Morse plans his telegraph (32).
35.	**Queen Victoria** (1837–1901).	Screw propeller for steamships invented (36). *Great Western* crosses Atlantic by steam alone (38).
40.		Wheatstone and Cooke set up telegraph in England (43).
45.	Lord Shaftesbury's work on behalf of child workers (47).	Morse sets up telegraph in America (45). Howe's sewing-machine (46). Simpson experiments with chloroform.
1850.		Robert Stephenson's tubular bridge, Menai Strait (50).
55.	Crimean War (54–56). Indian Mutiny (57).	First Atlantic cable laid (57). South Foreland lighthouse lighted by electricity (58).
60.		
65.		Pasteur at work on microbes (65). Lister at work on antiseptics (65). Lallement patents his "bicycle" (65).
70.	Franco-German War (1870–1).	
75.		Bell's telephone (76). Edison at work on the phonograph (77–78).

	Politics.	Industries and Inventions.
1880.	First Boer War (1880-81).	Edison's electric lamp (80).
		Douglas builds the fourth Eddystone (82).
85.		Daimler's successful petrol-engine (85). First moving pictures (85). Starley's bicycle (85). Pasteur conquers hydrophobia (86). Berliner's gramophone (87). Pasteur Institute founded in Paris (88).
90.	Second Boer War (1899–1902)	Dunlop's pneumatic tyre (88). Hertz detects Hertzian rays (88). First trial run for motor-cars (94). First cinema (95). Röntgen discovers X Rays (95).
95.		Lilienthal killed while "gliding" (96). Becquerel discovers "Becquerel Rays" (96). Marconi granted patent for wireless telegraphy (96). Curies separate radium (98). Pilcher killed while gliding (99).
1900.	**Edward VII** (1901–10)	Zeppelin's first airship (1900). First wireless signal across Atlantic (01). Wright's successful aeroplane flight (03).
05.		First British airship (05).
10.	**George V** (1910–1936).	Blériot flies the Channel (09).
	GREAT WAR (1914–18).	
15.		
	League of Nations (1919)	Alcock and Brown fly the Atlantic (19). Broadcasting begins (20).
20.		B.B. Company formed (22).
25.		
30.	Era of Conferences :— India (30; 31); Lausanne (32); Ottawa (32); World Economic Conference (32).	Telephonic communication with Australia (30).
		Launching of the *Queen Mary* (34).
35.	**Edward VIII** (1936–).	

INDEX.

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